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Current and emerging trends in U.S. agriculture and silviculture that will have the most significant environmental implications in both the short term (1985) and the long term (2010) are determined and assessed. Five major subsectors of agriculture and silviculture were included in the analysis: (1) nonirrigated crop production, (2) irrigated crop production, (3) feedlot production, (4) range and pasture management, (5) silviculture and harvest management. Within each subsector, numerous trends and developments were identified and defined by the Contractor. Thereafter, an evaluation workshop, comprised of subsector professionals from throughout the nation, evaluated, rated and rank-ordered the most significant environmentally related trends.

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ENVIRONMENTAL IMPLICATIONS OF TRENDS IN AGRICULTURE AND SILVICULTURE

Volume I: Trend Identification and Evaluation

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FOREWORD

Environmental protection efforts are increasingly directed towards preventing adverse health and ecological effects associated with specific compounds of natural or human origin. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, management or engineering tools are developed for assessing and controlling adverse environmental effects of non-irrigated agriculture and of silviculture.

Agricultural and silvicultural practices, already significant sources of water and air pollution, represent areas of increasing environmental concern as these production systems expand to meet growing population needs. This study assesses the environmental implications and effects of short- and long-term trends in American agriculture and silviculture and identifies research needs and policy issues. The developed information should benefit environmental managers as they attempt to anticipate pollution problems of the future.

David W. Duttweiler
Director
Environmental Research Laboratory
Athens, Georgia

PREFACE

The results of this research study, i.e., "Environmental Implications of Trends in Agriculture and Silviculture," are presented in two parts: Volume I: Trend Identification and Evaluation, and Volume II: Environmental Effects of Trends.

Volume I identifies, defines, rates and rank-orders the most important environmentally-related trends within all major subsectors of agriculture and silviculture. The environmental ratings and rankings were made by selected panels of professionals from throughout the nation, given the Contractor's interim report of trend-by-trend assessments. Over 240 specific subtrends, representing over 70 trend groupings, were evaluated across five panel areas, i.e., subsectors of agriculture and silviculture. These panel areas were: (1) Nonirrigated Crop Production, (2) Irrigated Crop Production, (3) Feedlot Production, (4) Range and Pasture Management, and (5) Silviculture and Harvest Management. Separate sections of the Volume I report are devoted to each of these panel areas of study.

Volume II extends the environmental assessment for major trends from each panel area, primarily the crop production subsectors. Ultimately, the main evaluations of Volume II were assessments of each trend's probable ecological effects, i.e., aquatic life, terrestrial life and human health impacts. These evaluations were also completed by professionals in a workshop setting given the Contractor's background summary of detailed findings for each trend-subtrend. Volume II also contains an assessment of continuing research needs and prospective policy issues involving agriculture and silviculture and environmental quality management.

Throughout the study both short term (1985) and long term (2010) effects were evaluated, although emphasis was placed on the long term. Furthermore, the study considered beneficial as well as adverse effects of trends in agriculture and silviculture. The intent was that the nation's environmental quality can perhaps be as readily enhanced through the promotion of beneficial trends as through the control of adverse trends. Finally, the research approach of this study relied heavily upon the value judgements of professionals from agriculture, silviculture and the basic sciences. This approach was regarded as essential given our current data and knowledge of the environmental effects of agriculture and silviculture. On balance, we believe that the composite, informed professional judgements as presented herein are most reflective of the environmental implications of trends in agriculture and silviculture.

ABSTRACT

This study determined and assessed those current and emerging trends in U.S. agriculture and silviculture which will have the most significant environmental implications in the future. Volume I, the first of two volumes, delineates trends and presents a general environmental implications assessment of trends and developments in all major subsectors of agriculture and silviculture; and Volume II presents a more detailed environmental assessment of selected major trends, including specifically an assessment of each trend's ecological effects. The study considered beneficial as well as adverse environmental implications in the assessment process; and, further, assessed the environmental implications of trends in both the short term (1985) and the long term (2010).

Five major subsectors of agriculture and silviculture were included in the analysis: (1) Nonirrigated Crop Production, (2) Irrigated Crop Production, (3) Feedlot Production, (4) Range and Pasture Management, (5) Silviculture and Harvest Management. Within each subsector, numerous trends and developments were identified and defined by the Contractor. Thereafter, an evaluation workshop, comprised of subsector professionals from throughout the nation, evaluated, rated and rank-ordered the most significant environmentally-related trends both by subsector designation and across subsectors of agriculture.

A more detailed evaluation was made of selected trends from among the leading five trends from each panel area in the second part of the study. Namely, additional research was conducted on the extensiveness of each trend, resource use implications, productivity changes and pollutant changes by media. Additionally, a second workshop emphasizing ecological effects of the major trends was conducted to ascertain probable aquatic life, terrestrial life and/or human health impacts associated with these trends.

The study further determined relevant research needs to enhance subsequent environmental implications assessments in agriculture and silviculture, and enumerated probable policy issues involving the agriculture and silviculture sectors and environmental quality management. These research needs and policy issues are also described in Volume II.

This report was submitted in fulfillment of EPA Contract No. 68-03-2451 by Development Planning and Research Associates, Inc., Manhattan, Kansas, and its subcontractor, The Tuolumne Corporation, Corte Madera, California, under the sponsorship of the Environmental Protection Agency. Work was completed as of August, 1977.

CONTENTS

FOREWORD iii
PREFACE iv
ABSTRACT v
LIST OF EXHIBITS x
ABBREVIATIONS xiii
ACKNOWLEDGEMENT xiv
EXECUTIVE SUMMARY xvi

I. INTRODUCTION 1
- A. Scope of Study 1
- B. Procedures and Assumptions 2
- C. Definitions 4

II. ENVIRONMENTAL ISSUES INVOLVING AGRICULTURE AND SILVICULTURE 5
- A. Major Pollutants and Their Sources 5
  - 1. Pesticides 5
  - 2. Nutrients 8
  - 3. Soil Sediment and Heavy Metals 9
  - 4. Salinity 9
  - 5. Other Pollutants and Sources 9
- B. Potential Environmental Effects of Pollutants from Agriculture and Silviculture 11
  - 1. Water Pollution 13
  - 2. Soil Pollution 15
  - 3. Air Pollution 16
  - 4. Potential Environmental Pollution From Other Agricultural and Silvicultural Practices 16
- C. Pollution Effects on Silviculture and Agriculture 17

III. A SCENARIO OF THE FUTURE: 1976-2010 18
- A. Output Projections 18
- B. Resource Availability 20
- C. General Assumptions 23
- D. Function of Moderate Growth Scenario 28

IV. THE EVALUATION WORKSHOP 30
- A. The Evaluation Workshop 30
- B. Workshop Procedures 31
- C. Participants 36

Preceding page blank

CONTENTS (continued)

V. THE LEADING ENVIRONMENTALLY-RELATED TRENDS: AGRICULTURE AND SILVICULTURE 38

VI. ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 1 - NONIRRIGATED CROP PRODUCTION 41
  A. Major Trend Rankings and Practices Assessments 41
  B. Environmental Implications of Major Trends and Practices 45
  C. Background Summary 49
    1. Overview and Base Data 49
    2. Trends and Environmental Implications 56

VII. ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 2 - IRRIGATED CROP PRODUCTION 74
  A. Major Trend Rankings and Practices Assessments 74
  B. Environmental Implications of Major Trends and Practices 78
  C. Background Summary 81
    1. Overview and Base Data 81
    2. Trends and Environmental Implications 89

VIII. ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 3 - FEEDLOT PRODUCTION 107
  A. Major Trend Rankings and Practices Assessments 110
  B. Environmental Implications of Major Trends and Practices 112
  C. Background Summary 115
    1. Overview and Base Data 116
    2. Trends and Environmental Implications 124

IX. ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 4 - RANGE AND PASTURE MANAGEMENT 135
  A. Major Trend Rankings and Practices Assessments 135
  B. Environmental Implications of Major Trends and Practices 136
  C. Background Summary 141
    1. Overview and Base Data 141
    2. Trends and Environmental Implications 144

X. ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 5 - SILVICULTURE AND HARVEST MANAGEMENT 156
  A. Major Trend Rankings and Practices Assessments 157
  B. Environmental Implications of Major Trends and Practices 161
  C. Background Summary 163
    1. Overview and Base Data 163
    2. Trends and Environmental Implications 167

CONTENTS (continued)

XI. WORKSHOP RANKING OF MAJOR TRENDS ACROSS PANELS 175

XII. CONCLUSIONS AND RECOMMENDATIONS 180
  A. Conclusions 180
  B. Recommendations 181

XIII. BIBLIOGRAPHY

APPENDIX A - THE EVALUATION WORKSHOP: PURPOSE AND PROCEDURES A-1

APPENDIX B - THE EVALUATION WORKSHOPS DETAILED PANEL RATINGS A-17

LIST OF EXHIBITS

Number		Page
1	Summary of each panel's ranking and adjusted ratings (AR) of major environmentally-related trends in agriculture and silviculture	xviii
2	Summary of workshop rankings of major trends in agriculture and silviculture	xix
II-1	Major pollutants from agriculture and silviculture	6
II-2	Representative rates of erosion from various land uses	10
II-3	Relative erosion from various land uses: Nationwide	10
II-4	A flow diagram of sources of environmental pollution and their implications	12
III-1	Exogenous variables: Projections under moderate growth assumptions on population, per capita personal income, housing starts, and gross national product with current environmental controls	19
III-2	Exogenous variables: Graphical representation under moderate rates of growth	19
III-3	Projections by commodity for selected years 1985 and 2010 under moderate growth assumptions	21
III-4	Projections index for agricultural resources for selected years 1985 and 2010 under moderate growth assumptions	22
III-5	Agricultural resources: Projections under moderate growth assumptions	22
III-6	Distribution of U.S. land by use category (estimated acres) 1975	24
III-7	Potential for copland with development necessary by land uses (estimated acres) 1975	25
III-8	Sources of "potential cropland" by current use (estimated acres) 1975	26
IV-1	Environmental implications of trends in agriculture and silviculture	32
IV-2	Rating system definition for the assessment of environment implications of trends in agriculture and silviculture	35
V-1	Summary of panel and workshop rankings of major trends in agriculture and silviculture, 1976-2010	39

LIST OF EXHIBITS (Continued)

Number		Page
VI-1	Ranking of environmentally-related trends, 1976-2010: Nonirrigated Crop Production	42
VI-2	Description of major environmentally-related trends, 1976-2010: Nonirrigated Crop Production	43
VI-3	Environmental ratings of top ten trends and associated practices: Nonirrigated Production	44
VI-4	Nonirrigated cropland as a percent of total cropland harvested: 1969	49
VI-5	Relative potential contribution of cropland to watershed sediment yields	51
VI-6	Location of cropland - corn, soybeans, cotton, wheat	53
VI-7	Acres receiving fertilizer and average fertilizer rates of four crops in the United States, 1974	54
VI-8	Croplands treated with pesticides and herbicides: 1969	55
VI-9	Crop production system: Nonirrigated Cropland	57
VI-10	Environmentally-related trends: Nonirrigated Cropland	58
VI-11	Description of environmentally-related trends and developments: Nonirrigated Cropland	61
VI-12	Environmentally-related trends: Nonirrigated Cropland	65
VII-1	Ranking of environmentally-related trends, 1976-2010: Irrigated Crop Production	75
VII-2	Description of major environmentally-related trends, 1976-2010: Irrigated Crop Production	76
VII-3	Environmental ratings of top ten trends and associated practices: Irrigated Crop Production	77
VII-4	Irrigated cropland harvested as a percent of total cropland harvested: 1969	82
VII-5	Irrigated cropland in specified crops and pasture on farms: 1969	83
VII-6	Irrigated cropland receiving high rates of fertilization	85
VII-7	Concentrations of feedlots which include dairy farms, beef, hogs, and chickens	87
VII-8	Croplands treated with pesticides and herbicides: 1969	88
VII-9	Crop production system: Irrigated Cropland	90
VII-10	Environmentally-related agricultural trends: Irrigated Cropland	91
VII-11	Description of environmentally-related trends and developments: Irrigated Cropland Production	94
VII-12	Environmentally-related trends: Irrigated Cropland	98
VIII-1	Ranking of environmentally-related trends, 1976-2010: Feedlot Production	108
VIII-2	Descriptions of major environmentally-related trends, 1976-2010: Feedlot Production	109

LIST OF EXHIBITS (Continued)

Number		Page
VIII-3	Environmental ratings of ten trends and associated practices: Feedlot Production	111
VIII-4	Cattle fattened on grain and sold for slaughter. Each dot represents 5,000 head	117
VIII-5	Milk cows. Each dot represents 1,000 milk cows	118
VIII-6	Hogs and pigs. Each dot represents 10,000 hogs	119
VIII-7	Broilers and other meat-type chickens. Each dot represents 500,000 chickens	120
VIII-8	Chickens 3 months old or older. Each dot represents 50,000 chickens	121
VIII-9	Livestock production projections	125
VIII-10	Livestock production system (feedlots)	126
VIII-11	Environmentally-related trends in agriculture: Feedlot production	127
VIII-12	Description of environmentally-related trends and developments: Feedlot Production	129
VIII-13	Overall trends in feedlot concentrations	132
IX-1	Ranking of environmentally-related trends, 1976-2010: Range and Pasture Management	136
IX-2	Description of major environmentally-related trends, 1976-2010: Range and Pasture Management	137
IX-3	Environmental ratings of top ten trends and associated practices: Range and Pasture Management	138
IX-4	Range and pasture systems	145
IX-5	Environmentally-related trends: Range and Pasture	146
IX-6	Description of environmentally-related trends and developments in range and pasture	148
IX-7	Environmentally-related trends: Ranges and Pastures	151
X-1	Ranking of environmentally-related trends, 1976-2010: Silviculture and Harvest Management	157
X-2	Description of major environmentally-related trends, 1976-2010: Silviculture and Harvest Management	158
X-3	Environmental implications of all silviculture trends, regional and national, 1976-2010	159
X-4	Environmental rating of top ten trends and associated practices: Silviculture and Harvest Management	160
X-5	Summary of softwood timber demands projected to 2020	164
X-6	Summary of hardwood timber demands projected to 2020	165
X-7	Silvicultural production system	168
X-8	Environmentally-related trends: Silviculture	169
X-9	Description of trends and developments: Silviculture and Harvest Management	171

LIST OF EXHIBITS (Continued)

Number		Page
XI-1	Summary of workshop rankings of major trends in agriculture and silviculture	176
XI-2	Panel's ranking of their top five trends within twenty major trends	178
A-1	Rating system definition for the assessment of environment implications of trends in agriculture and silviculture	A-3
B-1	Summary of all panel's rankings of twenty major trends	A-19
B-2	Summary of Individual participant's ranking of twenty major agriculture trends	A-20
B-3	Summary of individual participant's integration of second five trends (#6-#10), as identified by his panel, into major twenty trends	A-21

ABBREVIATIONS

The following abbreviations were used in the text of this research study.

DDE	- 1,1-dichloro - 2,2-bis (p-chlorophenyl) ethylene
DDT	- 1,1,1 trichloro - 2,2 bis (p-chlorophenyl) ethane
DDTR	- a compilation of all members of the DDT group
ERS	- Economic Research Service
FAO-WHO	- Foreign Agriculture Organization-World Health Organization
mg	- milligram, .001 gram
OBERS	- Bureau of Economic Analysis (formerly Office of Business Economics), U.S. Department of Commerce, and Economic Research Service, U.S. Department of Agriculture
ppb	- parts per billion
ppm	- parts per million
ppt	- parts per trillion
ug	- microgram, .000001 gram

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Particularly important to this study, also, were the individual and combined efforts of the evaluation workshop participants (both in the Volume I and Volume II portions of study) who assessed the environmentally-related trends in agriculture and silviculture, 1976-2010. These participants, as briefly named below by panel area, are identified further within the report. DPRA sincerely acknowledges their contributions.

Nonirrigated Crop Production
- George M. Browning, Ch.
- William L. Colville
- Pierre L. Crosson
- Velmar W. Davis
- Victor J. Kilmer
- Ralph L. Leonard
- Gary Margheim
- Walt H. Wischmeier

Irrigated Crop Production
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Range and Pasture Management
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Silviculture and Harvest Management
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Samuel G. Unger
Principal Investigator

EXECUTIVE SUMMARY

This study for the Environmental Protection Agency determined and assessed those current and emerging trends in U.S. agriculture and silviculture which will have the most significant environmental implications -- either beneficial or adverse. This Volume I report, the first of two volumes, presents a general assessment of numerous trends and developments in all major subsectors of agriculture and silviculture. Volume II presents a detailed assessment of selected major trends and their expected environmental effects.

A. Purpose and Scope of Study

The primary objectives of the overall study were:

(1) to assess the environmental implications of both short-term (1985) and long-term (2010) trends in American agriculture and silviculture, and
(2) to identify pertinent environmental issues, associated research needs, and policy issues.

Two phases of research were involved in the study:

(1) Phase I, the subject of this report, determined on a priority basis the major environmentally-related trends in agriculture and silviculture, and
(2) Phase II, assessed the environmental impacts of selected key-trends (i.e., quantified, where possible, their environmental effects) and identified research needs and policy issues.

B. Research Procedures

Phase I of the study was designed (1) to identify germane major pollutants stemming from agricultural and silvicultural practices and to describe their potential beneficial or adverse environmental effects, (2) to prepare from acceptable and documented ERS and OBERS data a moderate-economic-growth projection reflective of short-term (1985) and long-term (2010) agricultural and silvicultural product demands, and (3) to identify current and potential agricultural and silvicultural practices which impinge upon environmental concerns. Upon the basis of these three steps, a preliminary report of findings was prepared which served as a basis for a workshop evaluation conducted by representatives of Development Planning and Research Associates, Inc., Environmental Protection Agency, and the Tuolumne Corporation, a subcontractor to DPRA which assisted in preparing the silviculture part of this study.

The Evaluation Workshop brought together, in addition to EPA and Contractor representatives, twenty-six participants from throughout the U.S. and from a complex variety of appropriate scientific and technological disciplines. The group was divided into panels reflecting the agricultural and silvicultural sectors considered in the report, namely:

1. Nonirrigated Crop Production
2. Irrigated Crop Production
3. Feedlot Livestock Production
4. Range and Pasture Management
5. Silviculture and Harvest Management

Taking as their data base the preliminary report prepared by DPRA, the participants modified that data where necessary and (a) identified the key agricultural and silvicultural trends by panel area, (b) assessed the environmental effects of their composite practices, (c) assigned environmental ratings to each trend, and (d) ranked, in the order of their importance, the leading twenty agricultural and leading five silvicultural trends.

Following the Evaluation Workshop, DPRA assessed the workshop's findings and prepared the present report.

C. Organization of Report

This Volume I report organizes the findings of the Phase I study as follows:

Section I: discusses the major components of the study and briefly describes its procedures and assumptions,
Section II: surveys germane biological and chemical pollution data and discusses the affect of such pollutants on air, water, and land eco-systems,
Section III: presents and discusses the economic growth model data pertinent to agriculture and silviculture resources and demands,
Section IV: describes the Evaluation Workshop and its procedures,
Section V: presents, as an overview previous to further discussion in succeeding sections, the rankings of the leading trends in each sector considered in the report.

Sections VI-X: presents for each panel area (a) the major trend rankings and their composite practices assessments, (b) the environmental implications of those trends and practices, and (c) the preliminary overview base data descriptive of the major trends and practices,

Section XI: presents the Evaluation Workshop's integrated rankings of the leading twenty agricultural and leading five silvicultural trends,

Section XII presents this report's conclusions and recommendations, and the

Appendices: presents additional workshop procedural details and supplemental workshop trend rankings.

D. Results of the Study

1. Rankings of Panel Trends

The major results of this study are the rankings of the five most environmentally-related trends in each of the agricultural and silvicultural subsectors in the study.

Each of the Evaluation Workshop panels delineated, assessed, rated and, finally, rank-ordered the major environmentally-related trends (and probable developments) in its subject area, i.e., Nonirrigated Crops, Irrigated Crops, Feedlot Production, Range and Pasture Management, and Silviculture and Harvest Management. A summary of each of the panel's leading trends is shown in Exhibit 1.

The trends shown are only part of the findings by each panel. The remaining trends (a total of 71) and also subtrends (a total of 241) are described in detail in the text. However, the twenty-five trends as listed in Exhibit 1 adequately illustate the range and diversity of environmentally-related trends which occur in the agriculture and silviculture sectors of the economy. Associated environmental problems are, consequently, diverse and potentially complex.

Also shown in Exhibit 1 are the panel's "adjusted rating" scores which reflect the relative environmental importance--based upon the panel's judgements--of each of the leading trends (a maximum absolute score of 25 was permitted). However, caution is advised in making comparisons across panels since each panel independently applied the rating system of the workshop.

Next, and in accordance with the workshop procedures, the leading five trends from each panel were submitted to the general workshop for further evaluation and overall ranking.

Exhibit 1. Summary of each panel's ranking and adjusted ratings (AR) of major environmentally-related trends in agriculture and silviculture

Panel	Trend No. 1/	Trend	Initial Panel Rank of Top Five Trends	Panel Adjusted Rating (AR)
1. Nonirrigated Crop Production	(104)	Runoff & Erosion Control	1	18
	(119)	Improvement of Seeds & Plants (103 + 114)	2	16
	(101)	Conservation Tillage	3	14
	(120)	Scouting & Integrated Controls (112 + 117)	4	13
	(121)	Developing New Biological and Chemical Pesticides (115 + 116)	5	12
2. Irrigated Crop Production	(208)	Improving Water Application	1	22
	(204)	Runoff & Erosion Control	2	18
	(211)	Methods of Nutrient Application	3	15
	(220)	Developing Integrated Controls	4	12
	(210)	Using Plant & Soil Analysis	5	9
3. Feedlot Production	(308)	Feedlot Size	1	15
	(319)	Feedlot Design for Waste Management (306 + 311 + 312)	2	12
	(317)	Residual Disposal (312 + 315)	3	10
	(313)	Odor Control	4	9
	(318)	Feed Efficiency & Ration (302 + 305)	5	8
4. Range & Pasture Management	(406)	Grazing Practices: Range & Pasture	1	8
	(405)	Stocking Ranges	2	7
	(401)	Range & Pasture Renovation	3	6
	(416)	Using Increased Resources (411 + 415)	4	5
	(417)	Range & Pasture Improvement (402 + 404 + 407)	5	5
5. Silviculture and Harvest Management	(502)	Access to Timber Resource (Woods)	1	4
	(505)	Site Preparation	2	4
	(503)	Log Extraction	3	3
	(504)	Utilization (Logs & Residues)	4	2
	(510)	Fire Control	5	2

1/ The trend number denotes both the panel designation (first digit) and the sequence number (third and fourth digits) within each panel area. Also, the Workshop participants combined and/or redefined selected trends as indicated in the trend description if appropriate. These numbers are used throughout this report for reference purposes.

Exhibit 2. Summary of workshop rankings of major trends in agriculture and silviculture

Trend No.	Agriculture Trends	Workshop Rank
(104)	Runoff and Erosion Control (Nonirrigated)	1
(101)	Conservation Tillage	2
(208)	Improved Water Application	3
(204)	Runoff and Erosion Control (Irrigated)	4
(119)	Improvement of Seed and Plants	5
(120)	Scouting and Integrated Controls	6
(121)	Developing New Biological and Chemical Pesticides	7
(319)	Feedlot Design for Waste Management	8
(308)	Feedlot Size	9
(317)	Feedlot Residual Disposal	10
(211)	Method of Nutrient Application	11
(406)	Grazing Practices: Range & Pasture	12
(405)	Stocking Rates: Range & Pasture	13
(220)	Developing Integrated Controls	14
(401)	Range & Pasture Renovation	15
(210)	Using Plant & Soil Analysis	16
(313)	Odor Control	17
(416)	Using Increased Resources: Range & Pasture	18
(318)	Feed Efficiency and Rations	19
(417)	Range and Pasture Improvement	20

	Silviculture Trends	Rank by Panel 5 [1/]
(502)	Access to Timber Resource	1
(505)	Site Preparation	2
(503)	Log Extraction	3
(504)	Utilization (Logs & Residues)	4
(510)	Fire Control	5

[1/] Silviculture trends were rated separately by Silviculture Panel 5 and are not included in overall workshop rankings.

2. Rankings of Major Trends

With the understanding that only the most significant five trends from each panel were to be further assessed and ranked, the workshop concluded that the major trends of agriculture and of silviculture should be ranked as shown in Exhibit 2. The agriculture trends were purposefully separated from the silviculture trends.

Within agriculture, the trends occurring in Nonirrigated Crop Production tend to be ranked relatively high. Some trends in Irrigated Crop Production are relatively important and are followed by key Feedlot Production trends. Range and Pasture Management trends are generally ranked in the lower half of the leading agriculture trends (two trends, however ranked near the mid-range of the rankings).

The silviculture sector's leading five trends are shown separately. While the original workshop procedures requested a joint-ranking of agriculture and silviculture trends, a judgement was made to separate the two sectors. This decision was reached after deliberations both by the workshop as a whole and, especially, by the Silviculture Panel. In part, the separation reflects the Silviculture Panel's reluctance to rank the agriculture panels' trends, and vice versa. Also, however, a genuine concern exists in comparing (without more quantified environmental data) the environmental implications of largely different production sectors (e.g., forestry produces on a 30 to 60 year or more growth cycle; agriculture produces intensely on basically an annual growth cycle). In addition, silviculture is relatively more concerned with environmental factors such as ecological disruptions, wildlife habitat and aesthetics than is agriculture. On balance, however, a general observation of the workshop was that silviculture trends would tend to be ranked in the lower half of the trends shown when such ranking considers basic soil, water and air media effects only.

A further observation of the workshop was that the major trends shown in Exhibit 2 would include some secondary trends (such as trends 6 to 10 of Nonirrigated Crop Production) if these trends had been included in the ranking procedure. Again, this limitation must be assessed independently--which is done in the text of this summary report.

E. Directions for Future Study

The objectives of this Phase I report were realized--the major environmentally related trends of agriculture and silviculture were evaluated and ranked--under a rather strict set of guidelines and within a limited scope of study. As a byproduct of the workshop, Development Planning and Research Associates recommended that additional attention be focused on the following factors in future efforts to assess the environmental implications of trends in agriculture and silviculture.

1. Regionalization of Trends. Regional variations in the significance of specific trends should be assessed.

2. Segmentation of Panel Areas. Further segmentation of a panel area is warranted. For example, species categorization for Livestock and the separation of ranges and pastures in Range and Pasture Management would provide additional important results.

3. Additional Trends. The trend coverage of the workshop was comprehensive but not exhaustive. Some panelists voiced concern for potential but as yet not fully realized research that may significantly affect agriculture and silviculture production. Their assessments would complement this report.

4. Quantified Environmental Data. Few empirical data exist for quantitative national assessments of expected environmental effects. The Workshop was primarily founded on the principal that informed value judgements were our best resource for the evaluations. An improved quantitative data base is highly desirable.

5. Public and Private Support of Trends. The Workshop was generally optimistic about the continuation of public and private support of sound, realizable environmentally-related policies and programs, e.g., soil conservation, improved management systems, farm policies, etc. However, further study is warranted of the infrastructures that are necessary to maintain viable, environmentally responsible agriculture and silviculture sectors of the U. S. economy.

6. Rating System Improvements. The rating system utilized by the workshop was effective as implemented by each panel. However, refinements might be made to facilitate the use of rating scores across panel areas.

7. Time Frame. The Workshop was constrained by time to focus principally on the long-term future, i.e., 2010. Further assessments of the short-term future were recognized as important, especially since some environmental effects could worsen in the near future prior to the adoption by the majority of the farmers and foresters of improved management practices which will eventually provide beneficial environmental effects relative to current practices.

In conclusion, Development Planning and Research Associates regards the identification and ranking of the leading trends in each panel area as the principal results of the Evaluation Workshop. Secondly, the overall rankings across panels in agriculture, and separately for silviculture, are informative and helpful in the aggregate; however, from the standpoint of balanced environmental policies and programs, each panel area represents a major, diverse segment of the economy which will require focused attention and management resources if future environmental improvements are to be realized.

SECTION I

INTRODUCTION

Agricultural and silvicultural management systems in the United States contribute to environmental pollution. Although these pollutants (residuals of the production systems) are dispersed throughout the nation, their environmental implications are consequential both in the aggregate and where local-regional concentrations of pollutants occur.

Nationally, the agricultural and silvicultural sectors of the economy are important sources of water, air and soil pollutants. They are jointly the largest source of suspended solids (e.g., sediment, nutrients) and biological pollutants (e.g., cropland, feedlot, grassland and forest residues) in surface waters. On the local-regional level, specific environmental damages have at times been traced to the detrimental impacts of agriculture-silviculture residuals, per se. Also, air (e.g., dust, smoke, odor) and soil (e.g., salinity) pollution problems are potentially serious on a local-regional basis.

As the agricultural and silvicultural sectors continue to increase output through both intensive and extensive management practices, even greater aggregate levels of residuals and/or local-regional concentrations may occur; therefore, an assessment of the environmental aspects of critical trends within these sectors of the economy is warranted.

A. Scope of Study

This study for the Environmental Protection Agency sought to determine those current and emerging trends in U.S. agriculture and silviculture which will have the most significant environmental implications--either beneficial or adverse. The primary objectives of the study were:

(1) to assess the environmental implications and impacts of both short-term (1985) and long-term (2010) trends in American agriculture and silviculture, and

(2) to identify pertinent environmental issues, associated research needs and policy issues.

Two phases of work were involved in the overall study:

Phase I, the subject of this Volume I report, determined on a priority basis the major environmentally-related trends in agriculture and silviculture, and

Phase II, the subject of the Volume II report, assessed the environmental impacts of selected key trends (i.e., quantified their effects where possible) and will identify research needs and policy issues.

Included within Phase I was a workshop conference of selected agricultural and forestry experts. This conference group assisted the Contractor in determining those trends of major significance and helped assess their related environmental implications.

B. Procedures and Assumptions

Prior to the workshop evaluation, the Contractor prepared a background summary report, primarily a reference document which served as the data basis for the workshop conference of agricultural and silvicultural experts. The report categorized and enumerated the principal environmentally related trends and developments within agriculture and silviculture as identified by the Contractor. The workshop participants were asked to further judge the significance of these trends and developments according to procedures as setforth herein. Where necessary, the workshop participants were advised to modify the Contractor's preliminary data and assumptions.

The evaluation workshop group was divided into five panels to cover various aspects of agriculture and silviculture as follows:

Agriculture
- Nonirrigated Crop Production
- Irrigated Crop Production
- Feedlot Livestock Production
- Range and Pasture Management

Silviculture
- Silviculture and Harvest Management

Workshop participants participated in their respective panels and in general sessions in order both to identify major trends within their major areas of expertise and to assess the overall relative importance of all major trends across the five panel areas. The detailed procedures and workshop agenda are described further in the Appendix of this report.

Using the Contractor's preliminary data base as a guide, the workshop panelists reviewed the identified trends for validity and completeness and rated the key environmentally-related trends in agriculture and silviculture. The results of the workshop, as summarized herein, served as principal input into Phase II over the overall study.

The framework of study required that trends and developments in agricultural and silvicultural production be assessed for the period 1976-2010. Obviously, many alternative production projections could reasonably be given based upon differing assumptions as to population growth rates (domestic and world), economic growth rates (e.g., gross national product), the levels of technological developments, the levels of foreign trade, and alternative governmental policies affecting energy, environment, employment, etc. The study to be uniformly consistent utilized one selected "scenario" of production which reflects moderate growth in agriculture and silviculture.

The selected source for the future projections of agriculture and silviculture was the OBERS Projections of the Water Resources Council as prepared by the U. S. Department of Commerce and the U.S. Department of Agriculture. In addition, the contractor used data supplemental to this projection as published by the Economic Research Service of the U. S. Department of Agriculture in its current publication "Agriculture, The Third Century."

The rationale for choosing a specific scenario projection is that the present study, with its limited scope, was to emphasize the assessment of the environmental implications for one level of economic development rather than assess the implications of alternative futures. To be sure, the trends and developments in agriculture and silviculture would be quantitatively impacted by changes in the baseline scenario; however, the basic environmental implications of such trends would not be largely altered. (Note: the most demanding impact of agriculture on the environment would result if foreign trade (export demand) were assumed high enough to require the utilization of significantly more new cropland acreage. Unless such does happen, the trends and developments are likely to continue as described herein.)

A scenario of the future--1976-2010--is described in section III, below. For comparison, alternative agricultural output levels which are about 20 percent higher to about 10 percent lower in 2010 than the baseline projection of this study have been projected. This range of aggregate output levels suggests the degree of future variability that may be contemplated. Again, however, this study sought to identify and assess those trends in agriculture and silviculture which are expected in association with the baseline scenario case. The emphasis is on those trends which are deemed to have the most significant environmental implications--either beneficial or adverse.

C. Definitions

Agriculture will refer only to those activities directly involved with farming, including crop production (nonirrigated and irrigated), livestock production, and range and pasture management. Agribusiness activities such as processing, distribution and farm supply are not included.

Other agriculture-related activites, e.g., strip mine reclamation and wetlands management, were also excluded from the study. Trends and developments in these areas are clearly of concern to the Environmental Protection Agency, but these remaining areas were not included in this study's scope of work.

Silviculture will refer to both forest production and harvest management in this study. Silviculture commonly refers to the establishment, composition, constitution and growth of forests. The harvesting of forest products, including area access and logging are incorporated herein as an integral part of overall forest management.

For both agriculture and silviculture, the primary focus will be toward those trends and developments which occur or are implemented on-site, i.e., at the farming or producing location. Off-site activities, such as food processing or lumber milling are not included in the study.

SECTION II

ENVIRONMENTAL ISSUES INVOLVING AGRICULTURE AND SILVICULTURE

Besides their most recognized and generally useful outputs, agricultural and silvicultural systems also produce residuals which affect various environmental media, including:

- surface water (quality and supply)
- groundwater (quality and level)
- air (quality)
- soil (composition)

The presence of such residuals does not necessarily represent an environmental hazard, for most ecosystems have natural sources of residuals (sediment, nutrients, etc.) which are utilized in food chains; however, if toxic substances or excessive quantities of residuals are discharged into ecosystems, the subsequent uses of these environments are detrimentally affected.

A. Major Pollutants and Their Sources

Major pollutants from agriculture and silviculture activities include sediment, plant nutrients, heavy metals, salts, biodegradable organics, pesticides, pathogens, odors, and fugitive dusts. These residues, plus others, stem from the various sources summarized in Exhibit II-1. A discussion of these pollutants and their effects follows.

1. Pesticides

Pesticide residues are pollutants from irrigated and non-irrigated croplands, from silviculture practices, and occasionally from range and pasture lands. Cropland pesticides constitute the largest source of these residues; smaller amounts are contributed by silviculture, range, and pasture land managements. The residues contaminate surface water, ground water, soil, the earth's atmosphere, and the human food chain.

Water loading. Pesticides reach water through direct surface run-off (pollutants dissolved in solution and bound on sediment), ground water seepage, aerial drift during application, and by being redeposited in waters upon volatilization. The literature on pesticide levels in U.S. waters and in surface run-off exhibits a wide variety of results reflecting regional differences in pesticide usage, different experimental techniques, and assay methods. The percentage of the total applied pesticide which appears in surface run-off ranges from 0.05 percent trifluralin, 0.12 percent durion (Williss, 75), 2-4 percent chloro-s-triazines (Hall, 72 74: White, 67) to as much as 7.01 percent dichlobenzil and 11.4 percent atrazine (Bailey, 74). (The higher percentages for atrazine and dichlobenzil

Exhibit II-1. Major pollutants from agriculture and silviculture

	Pollutant						
Source	N	P	Salts	Biodegradable Organics	Sediment	Pesticides	Microorganisms
Crop Production							
Small Grains	X	X	X	X	X	X	
Row Crops	X	X	X	X	X	X	
Hay and Forage	X	X	X	X	X	X	
Fruits	X	X	X	X	X	X	
Vegetables	X	X	X	X	X	X	
Pasture and Rangeland	X	X		X	X	X	X
Livestock Production							
Dairy	X	X		X		X	X
Beef							
Pasture	X	X		X	X	X	X
Confinement	X	X		X		X	X
Hogs	X	X		X		X	X
Poultry	X	X		X		X	X
Sheep	X	X	X	X	X	X	X
Idle Land	X	X		X	X	X	
Farm Woodland	X	X		X	X	X	
Silviculture	X	X		X	X	X	X

Source: A. Aleti, and others, "Methods for Identifying and Evaluating the Nature and Extent of Non-point Sources of Pollutants from Agriculture." In: Processing and Management of Agricultural Waste. Proceeding of the 1974 Cornell Agricultural Waste Management Conference, 1974.

resulted from a simulated hundred-year storm frequency within one hour of pesticide application. Under typical conditions, less than 5 percent of the applied pesticides are estimated to enter surface water from run-off (USDA-EPA, 75)).

Surface run-off pesticide concentrations depend upon the pesticide solubility, soil type, application techniques, quantity applied, and the amount and timing of rainfall. (Guenzi, 74; McElroy, 76)

Pesticide residue levels in U.S. waters vary from non-detectable amounts to 1,000 ppt for DDT (Edwards, 73; Holden, 75). Analyses show that few rivers exceed 10 ppt DDT or 5 ppt DDE. Residue levels of other pesticides were lower, usually below detection limits. Reported pesticide levels in city water supplies have been minor.

Soil residues. Soil residues of pesticides have been documented by both the U.S. Soils Monitoring Service and individual investigators. The soil residue levels range from non-detectable limits to highs of 107.45 ppm arsenic (presumably, though not necessarily, from non-agricultural sources), 78.4 ppm DDTR, and 35.92 ppm of p.p. DDT (Wiersma, 71, 72). The most widely spread residue was dieldrin, occurring in 30 percent of the tested sites. DDTR had the highest mean level of 0.31 ppm in cropland soil. Most other pesticide mean residue levels ranged from less than 0.01 ppm to 0.06 ppm. On occasion, soils from non-agricultured areas were shown to contain pesticide residues.

The persistence of soil residue pesticides depends upon their chemical properties. DDT, DDTR, and dieldrin are organochlorine pesticides, are considered persistent,and are found in their active form in the soil from 3 - 5 years after application. Phosphate insecticides, such as parathion and diazion, are non-persistent and usually disappear within 1 - 3 months. Other pesticides, including herbicides, persist from a few weeks to 18 months.

Atmospheric contamination. Pesticides enter the air through aerial drift upon application and volatilization following application. Residue levels in the atmosphere range from 0.0003 ppt-0.158 ppm (Edwards, 73) with a mean value of 0.001 ppb - 0.002 ppt. They have been found world-wide in the atmosphere.

Some investigators believe volatilization is the chief source of the pesticide residues in the atmosphere. Woodwell (71) estimates that as much as 50 percent of applied DDT ends up in the atmosphere; however, other investigators find this value to be high (Edwards, 73). Volitilization may result in 2.9 percent of the applied dieldrin ending up in the atmosphere. Large losses of pesticides to the air result from aerial drift during application. Under adverse weather conditions, 50 percent of aerial applied pesticides may never reach the target area (Edwards, 73; Spencer, 75).

Food residues. Food in the human food chain receives pesticide residues from direct uptake by crops, and from the tissues of birds, fish and other animals. Fish tissue concentrates can be 100 times the water level of pesticides (Edwards, 73). While some animal tissue tested does exceed recommended safety limits for pesticide residue levels, they are usually within these limits. Food crop pesticide residues are well within the limits set up by FAO-WHO; the highest levels found are only 10 percent of the safety limit.

2. Nutrients

Agricultural and silvicultural residues of nitrogen and phosphorus enter surface and ground waters from run-off and leaching losses associated with animal wastes and from movement of sediments into surface waters. Estimates of total nitrogen contributed to the nation's waters varies from 1,500 to 15,000 million pounds per year from rural agricultural land, and 400 to 1,900 million pounds per year from rural non-agricultural lands. The total phosphorus loading in U.S. waters is estimated at 120 to 1,200 million pounds per year from rural agricultural land and 150 - 750 million pounds per year from rural non-agricultural lands (Dornbush, 74).

The total amounts of nitrogen and phosphorus lost to pollution are dependent upon a number of variables. For cropland, these include application rates, soil properties, terrain, soil erosion tendencies, crop management practices, and rainfall amounts. Many experiments have determined the amount of nitrogen and phosphorus lost to waters in individual agricultural situations. The estimates of total applied nitrogen which reach surface waters vary from 15 - 54 percent (EPA, 73; NAS, 72). Ranges of total applied nutrients lost to surface waters are 0.03 - 8.4 pounds per acre for nitrogen and 0.01 to 0.80 pounds per acre for phosphorus (Dornbush, 74). Practices which reduce run-off and soil erosion will tend to reduce nutrient losses to streams. (Caution: The loading and concentration values of pollutants per event are generally of more environmental significance than annual runoff values--absolute or percentage.)

Leaching and run-off losses of nutrients from undisturbed forest areas and range lands are usually small, but increasing fertilization practices, clear cutting, and high stocking rates tend to increase the nutrient transport from these sectors. In one selected case of forest fertilization, nitrogen run-off increased from 0.48 pounds per acre to 0.62 pounds per acre for urea fertilizer and to 0.92 pounds per acre for ammonium sulfate fertilizers (Cole, 65). Experimental clear cutting under conditions dissimilar to those used in silvicultural practices increased nitrogen loading from 1.78 pounds per acre to more than 53.5 pounds per acre per year (Bormann, 68). These selected studies are but representative of the type of increases that can occur, and they are not national figures or averages. An increased loss of nutrients occurs from range and pasture land without adequate cover to protect surface soil against erosion.

Run-off and leaching losses of nutrients from animal wastes in housing and productive units occur, but the extent of this loss varies by geographic area, size and type of animal unit, and type of waste disposal system used. Closed confined housing of animals minimize potential pollution when wastes are properly disposed. Open feedlots present the severest hazard to potential pollution: a 32,000 head feelot can produce 1,400 metric tons of nitrogen yearly (comparable to the nitrogen waste of 260,000 humans (NAS, 72)). The nitrogen content of the soil under a Colorado feedlot was 1,143 pounds per acre compared to 403 pounds per acre for irrigated fields, 208 pounds per acre for cultivated dry lands, and 72 pounds per acre for native grasslands (NAS, 72). Pollution potential from animal wastes is greatest when the waste is spread on snow or frozen ground.

3. Soil Sediment and Heavy Metals

Soil sediment enters the nation's waters from all agricultural and silvicultural segments, and it is a transport agent of heavy metals, pesticides and plant nutrients. Any practice that increases(or reduces) sediment transport affects heavy metals transport similarly. Slope, cover crop cultivation practices, and timber harvest methods influence the amount of sediment lost. EPA (76) estimates that 5,200,000 tons of sediment are deposited in U.S. waters each day from cropland, 3,400,000 tons per day from range and pasture land, 720,000 tons per day from forests, and 57,000,000 tons per day from urban sources. Exhibits II-2 and II-3 show relative comparison rates of erosion stemming from various land uses. The exhibits show total erosion from cropland is 168 times greater than total erosion losses from commercial forests; however, no actual or potential erosion rates are available because of the localized nature of erosion losses. Individual testing of sediment losses show ranges from less than 1 ton per acre yearly to more than 21 tons per acre yearly. Many tests reported values of 7 - 8 tons per acre per year (Dornbush, 74). (Note: Multiple transport modes exist. Water flow may transport more wastes, with less concentration, because of its high volume. Also, some wastes, e.g., heavy metals, may be chelated with organic matter as well as transported with sediment.)

4. Salinity

Salinity results from irrigated crop practices, as well as occurring naturally, and affects the quality of ground water and surface water, and the soil productivity. Irrigation techniques are now 30 - 70 percent efficient. Practices which increase irrigation efficiency will demonstrate potential benefits by decreasing salinity in soil and return flows.

5. Other Pollutants and Sources

Drugs, hormones, and other chemicals are used as implants and feed additives to increase animal feed efficiency and rates of gain. Their use causes concern because they may be present in animal tissues at slaughter. Some of these residues are not destroyed by cooking, and the long term effects of small doses on humans have not yet been determined.

Exhibit II-2. Representative rates of erosion from various land uses

	Erosion Rates		
	Metric Tons/ sq km/year	Tons/ sq mi/year	Relative to Forest = 1
Forest	8.5	24	1
Grassland	85	240	10
Abandoned Surface Mines	850	2,400	100
Cropland	1,700	4,800	200
Harvested Forest	4,250	12,000	500
Active Surface Mines	17,000	48,000	2,000
Construction	17,000	48,000	2,000

Source: EPA, Methods for Identifying and Evaluating the Nature and Extent of Non-Point Sources of Pollutants, 1973.

Exhibit II-3. Relative erosion from various land uses: Nationwide

	Relative Erosion Values
Commercial Forests (Erosion index base = "1")	1
Abandoned Surface Mines	< 1
Active Surface Mines	2
Construction	6
Harvested Forests	11
Grassland	11
Cropland	168

Note: This index represents approximate relative rankings of the contributions of sediment (on-site), on a nationwide basis, from the seven types of non-point sources listed in Exhibit II-2 above.

Source: EPA, Methods for Identifying and Evaluating the Nature and Extent of Non-Point Sources of Pollutants, 1973.

Wind erosion pollutes U.S. waters and degrades soil quality. Valuable top soil is lost, land productivity may decrease and gullies may form. Severely eroded land may also be aesthetically displeasing.

Other sources of pollutants may develop in the future. For example, integrated pest management practices may be a source of additional bacteria and viruses. Also, crop residues associated with no till management practices may be a source of insect, rodent and disease vectors.

Surface run-off and leaching from animal waste disposal areas may increase microbial populations in the soil and water, but they are not considered serious pathogens. The size of the animal production units and the type of waste disposal systems used will determine the significance of microbial pollutant quantities.

Irrigation practices have resulted in lower ground water levels in many sections of the U.S. and land subsidence is a severe problem in some locations.

Smoke, dust, and odors arise from certain agricultural and silvicultural practices and contribute to air pollution. Smoke comes from prescribed and slash burnings in silviculture and agriculture. Wind erosion, cultivation practices, and harvesting methods create fugitive dust problems. Odors arise from cattle feedlots and other animal production units.

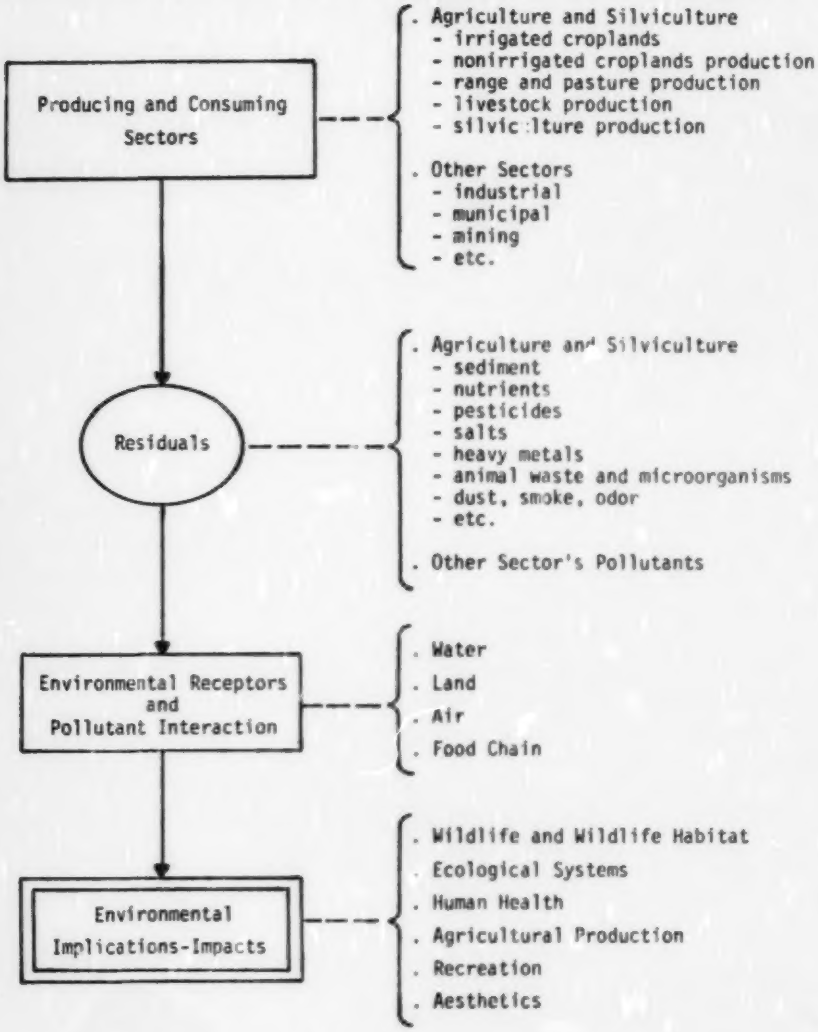
Thermal pollution from silviculture raises the temperatures of some streams above the endurance levels of some fish and enhances the foreutrophication of streams. Forest streamside cutting is the major cause of thermal pollution.

B. Potential Environmental Effects of Pollutants from Agriculture and Silviculture

The potential environmental effects of pollutants from agriculture and silviculture often cannot be directly or separately assessed. Various other sources of pollutants may be regularly mingled within common environmental receptors -- streams, rivers, lakes, and airsheds; consequently, synergistic pollutant effects and associated environmental implications may result.

As an aid to assess the potential environmental implications of trends in agriculture and silviculture, a schematic relationship of agriculture (and silviculture) to other sources of pollution and their linkage to a common environment is shown in Exhibit II-4. Within this framework, the ultimate end-uses of environmental resources (water, air, land) are shown to be the main determinants of the environmental implications of concern, for the impact of pollutants on subsequent uses of the environmental resources gives rise to man's concern for pollution.

Exhibit II-4. A flow diagram of sources of environmental pollution and their implications


Producing and Consuming Sectors
. Agriculture and Silviculture
- irrigated croplands
- nonirrigated croplands production
- range and pasture production
- livestock production
- silviculture production
. Other Sectors
- industrial
- municipal
- mining
- etc.
Residuals
. Agriculture and Silviculture
- sediment
- nutrients
- pesticides
- salts
- heavy metals
- animal waste and microorganisms
- dust, smoke, odor
- etc.
. Other Sector's Pollutants
Environmental Receptors and Pollutant Interaction
. Water
. Land
. Air
. Food Chain
Environmental Implications-Impacts
. Wildlife and Wildlife Habitat
. Ecological Systems
. Human Health
. Agricultural Production
. Recreation
. Aesthetics

Clearly, agricultural and silvicultural pollutants enter the earth's water, air, and soil. Surface water and ground water have increased salinity, sediment, pesticide residues, plant nutrients, easily oxidizable organics from crop residues, pathogenic organisms, and heavy metals as a result of agricultural and silvicultural practices. Pesticides, plant nutrients, and salt contribute to soil pollution. Agricultural chemicals, dust, odor, and smoke are sources of air pollution. Soil erosion, clear cutting, loss of wetlands, and reduction of ground water levels all produce an impact on the environment.

The assessment of these pollutants upon the environment is difficult, however, because although potentially harmful environmental effects do exist, experimental data on their quantities and effects are inadequate. When residue levels are obtained, they are usually at sublethal concentrations. Since it is not possible to finitely assess their impacts on the environment, only their potential environmental effects will be considered here.

1. Water Pollution

By volume, sediment is the major pollutant in surface water, and it is also the transport agent for other residues: nitrogen, phosphorus, pesticides, bacteria, and heavy metals. Sediment obstructs stream drainage and irrigation canals, fills reservoirs and lakes, and creates turbidity. It becomes an obvious economic problem when it becomes necessary to clear canals and reservoirs of sediment.

Surface and ground waters have increased salinity from irrigation practices. Currently, there is no danger to human health from increased salinity in surface waters (Color, 74), and its control is primarily an economic issue, for it increases municipal and industrial water treatment costs and accelerates pipe corrosion. High salinity levels result in unpleasant water taste, hardness, and a loss of aesthetic quality.

Salt buildup in ground water directly affects crop yields which decrease in all soils with excessive salinity. Crop production has become economically infeasible in areas of toxic salt levels. This results in lost profits and productive agricultural land.

Increased levels of nitrogen compounds and phosphates in surface waters lead to excessive algae growth which clutters streams and overburdens a body of water's supply of dissolved oxygen. The resultant stagnation in shallow water can cause (1) increased mosquito population and their consequent threat to health, (2) a decrease in fish populations and other aquatic life (3) an overall decrease in animal and human water use, and (4) tastes and odors. From current available data, the possibility of stagnation occurring in anything other than shallow streams and ponds (and then only infrequently) does not seem likely (NAS, 72). High concentrations of nitrates in livestock water has been reported to cause cattle illness and death (NAS, 72). The chronic effects of sublethal doses of nitrates on humans and animals are not well documented. Although, experiments show reduced productivity in animals with long term exposure to high nitrate levels, animals are also known to adapt to long term nitrate levels.

Seepage of ground water containing high concentrations of nitrates into well waters is the major direct threat to humans from nitrates. The U.S. Public Health Service has set 10 mg of nitrate per liter as the upper safety limit, and many wells, as well as some surface waters, exceed these limits. The U.S. has had 350 cases of nitrate poisoning (41 fatalities) in infants reported since 1944 (NAS, 72). All but 5 cases were caused from well-water nitrate poisoning.

Pesticide residues in surface and ground waters have been reported by many investigators (Guenzi, 74; Edwards, 73; Dornbush, 74; Haque, 75). A wide range of residue levels were found, ranging from undetectable amounts to 1,000 ppt for DDT, but an analyses of many rivers show that few exceed 10 ppt DDT or 5 ppt DDE (Edwards, 73; Holden, 75). Generally, all pesticides are found in small concentrations within recommended limits. Of primary concern are the high levels of pesticide residues found in the tissues of birds, fish, and other aquatic life, for aquatic life can concentrate pesticides at several times the level found in water (Edwards, 73; Holden, 75). Tissues of fish used in the human food chain have been found to have pesticide residues exceeding safety limits set up by FAO-WHO, and the excessive pesticide loadings of streams caused by careless application or from accidental dumps by pesticide producers have been reported to cause massive fish kills (Edwards, 73; Nicholson, 67). Certain birds have impaired reproduction rates caused by thin shelled eggs being produced when pesticide residue levels are high. Other birds carry heavy pesticide levels in their tissue with no apparent effects (Edwards, 73). The longterm effects of sublethal doses of pesticides upon human and animal populations are not known. Although, little evidence supports the idea that pesticide residue levels in our environment are widely harmful, it is impossible to prove otherwise as well. Recent government investigations and independent research studies have implicated certain pesticides and other related agricultural chemicals as possible carcinogenic agents when ingested or inhaled, and previous "safe" limits are being re-evaluated in light of these possible carcinogenic effects (Environ. Sc., 76).

Little can be said on ground water pesticide levels. Obviously, high pesticide levels can contaminate well water, but no cases of human deaths or illnesses have been reported.

The thermal pollution of water by certain silvicultural practices (such as streamside cutting) can cause adverse effects on some aquatic life. Temperatures are raised to a level that certain fish cannot endure; however, in some instances, the increased water temperatures can create a more favorable environment for lower links in the food chain.

Bacterial contamination of surface waters from animal wastes have been determined by a number of researchers (Dornbush, 74; Eunhle, 70), and this is a potential hazard to human health. Salmonella bacteria, occasionally found in animal wastes, may live in water and can cause Salmonellosis in humans. One investigator (Kunhle, 70) found fecal and coliform counts, after a storm run-off, to be greater than those acceptable for swimming waters. The difficulty of analyzing data from bacterial counts in water supplies stems from the inability to differentiate human from animal sources of contamination.

The major non-point heavy metal loading of surface waters is carried by sediment. These metals are for the most part sparingly soluble in water, so that little of the total metal load is solubilized in surface water. Their impact on water quality is much less than what would be calculated on the basis of the total load discharged into a water supply (McElroy, 76). Iron and maganese contribute the largest part of heavy metal load into surface waters. Small amounts of arsenic, copper, lead, and zinc are also carried into surface and ground water from sediment. Isolated tests of high concentrations of these metals on fish, algae, and other aquatic life have shown them to be toxic. Temperature, water pH, dissolved oxygen, suspended solids, turbidity, as well as experimental condition variables all influenced the measured degree of the toxicity of each metal; therefore, no uniform standards of toxicity values for the metals have been reached by investigators. Most experiments have been carried out under laboratory conditions and do not reflect the true incidence of aquatic life poisoning by heavy metals (Battelle, 71). Because most of the literature on non-point source pollution from agriculture does not make mention of the potential environmental effects of heavy metals, these effects may be minimal for surface and ground water (Dornbush, 74; USDA-EPA, 75).

2. Soil Pollution

Increased soil salinity results in decreases in crop yields, land productivity, and profits. Salinity increases when irrigation practices such as evapotranspiration remove water from the soil and concentrate its salts.

Both persistent and non-persistent pesticides are also found as residues in soil. Persistent pesticides may remain chemically active in the soil for several years; non-persistent pesticides disappear within a few months of application. Of primary concern is the uptake by crops of soil pesticides which contaminate foods. Monitoring by the U.S. government has found pesticide residues in food to be well within the safety limits; thus, no danger is posed to human health at this time (Edwards, 73). Theoretically, pesticide buildup in the soil could present an economic threat through decreased crop yields; however, there is little evidence to support this theory. Pesticide residues may be considered a potential environmental threat if projected increased pesticide levels are realized. Pesticide residues may also affect soil microbial populations. Soil microbes are often necessary to maintain proper ecological balances, for they aid in nitrogen fixation, are sometimes the natural predators of plant pests, and often provide other natural benefits to plants. Although soil microbial populations may be slowly altered by pesticide residue levels, little documented evidence exists to support this theory (Guenzi, 74; Edwards, 73), and studies do show that pesticides applied in proper doses are not likely to acutely affect the microbial population.

3. Air Pollution

Agricultural and silvicultural residues contribute to air pollution. Pesticide application by aerial sprays result in drift losses, and pesticides may also volatilize into the air after soil application. The ranges of pesticide levels in the atmosphere were found from 0.0003 ppt to 0.158 ppm with a mean level of 0.01 ppb to 0.002 ppt (Edwards, 73). Research indicates that human inhalation of 2 - 32 ug of pesticides per day is possible (Tabor, 66), but since this represents only 2 - 5 percent of the total uptake of pesticides by a human (ARC, 70) it is probably not significant. Instances of illnesses and deaths from pesticide poisoning have been recorded, but these have resulted from direct contact during aerial application or from an individual being in the proximity of a freshly, heavily sprayed field (Edwards, 73). (The possible carcinogenic effects of pesticides when ingested or inhaled were previously discussed.)

Dust from agricultural practices such as harvesting and wind erosion enters the air as a pollutant and is a carrier of pesticides, plant nutrients, and heavy metals. While dust may be irritating to eyes, nose, and throat, and have detrimental effects on people suffering from bronchial illnesses and allergies, its effect on the environment is usually synergestic. By itself, dust is not significant as an environmental threat, but in conjunction with chemical residues, industrial and municipal effluents, auto exhaust, and other air pollutants, it will contribute to the overall degradation of air quality.

Odors arising from feedlots and dairy farms are aesthetically displeasing. Odors are objectionable, and they occasionally cause minor illnesses. The potential environmental effects of odors are limited, and they are not generally considered harmful to human or animal health.

Smoke results from some silvicultural, and range and pasture land management practices. Smoke is temporary and it has no lasting effects upon the environment.

4. Potential Environmental Pollution From Other Agricultural and Silvicultural Practices

Soil erosion results in losses of valuable top soil, changes soil structure, increases gully formation, decreases soil productivity, hampers farming operations, and increases costs for land renovation. In some instances, land may be left completely non-productive and aesthetically displeasing.

Drug and chemical residues in animal tissue for human consumption are a potential threat to humans. Even after cooking foods for long time periods, some drugs still remain chemically active in beef and pork. Current research seeks to determine the possible carcinogenic effects of these drug residues.

The conversion of forest land into cropland, pasture, and range land, the draining of wetlands for agricultural usage, and the stocking of range lands all disrupt ecological systems. Wildlife, wildlife habitat, and recreational areas are changed and often lost when land is put into productive agricultural use. Proper management practices will minimize these environmental effects.

The increasing usage of irrigation has lowered ground water levels to dangerously low levels in certain sections of the U.S. Eventually, many areas utilizing groundwater supplies will have to revert to their former land uses or be abandoned as water supplies become depleted.

C. Pollution Effects on Silviculture and Agriculture

The above discussion highlights the effects of agricultural and silvicultural pollutants on the environment; however, it is generally recognized that both agriculture and silviculture production systems may also be impacted by polluted environments. Pollution that affects agriculture and silviculture arises from three principal areas: municipal and industrial air pollution, municipal solid-waste disposals on agricultural lands, and salinity buildup from irrigation return flows.

Agricultural cropland and forests existing in close proximity to large cities may suffer significantly from air pollution. Ponderosa pine trees above the Los Angeles Basin are being killed from that city's air pollution. Chemicals in the air may cause leaf rot and other plant diseases. Leaf foliage is often coated with a layer of grime or chemical which screens sunlight and results in lower photosynthesis and plant evapotranspiration rates. Lead from automotive exhaust is deposited in the soil and is available for plant uptake. The total impact of air pollution on agriculture is difficult to assess, for its effects are localized and do not affect a large sector of agriculture. Field crop areas are usually affected less than large vegetable farm areas since the latter are often located close to cities.

Heavy metal contamination of soil and crops is the chief adverse effect of municipal solid waste disposal on agricultural lands. Crops concentrate heavy metals. Also, beef cattle fed corn silage grown on sludge sites can concentrate the heavy metals in their tissues, and the human consumption of this beef will result in further concentrations of these metals. Heavy metals deposited on the soil are also available for ground and surface water contamination. Ocean dumping of waste is not permitted because heavy metal concentrations adversely affect marine life. Heavy metals concentration in surface waters affects aquatic life. Industrial pretreatment to remove heavy metals would eliminate most adverse effects that stem from municipal waste. Although a potential threat does exist from human pathogens infecting crops and animals, various pathogen treatments and control procedures make this highly unlikely.

Agriculture adversely affects itself through its salinity buildup from irrigation practices. The need to use available water more efficiently has led to using irrigation return flows whose residue salts will further concentrate soil salinity. Agricultural productivity may suffer from this increased soil salinity.

SECTION III

A SCENARIO OF THE FUTURE: 1976-2010

An assessment of the environmental implications of trends in agriculture and silviculture requires, minimally, the establishment of a baseline projection of these sectors of the economy. Such a baseline projection, i.e., scenario of the future, is presented below for both the short-term (1985) and the long-term (2010). Alternative scenarios are obviously possible, and the associated environmental effects would differ from the baseline case. However, this study seeks to thoroughly survey and delineate all trends and developments within agriculture and silviculture that have major environmental implications. A single and widely accepted scenario of the future: 1976-2010, has been incorporated herein to accomplish the main objective. Additional research, beyond the scope of this study, is needed to assess the effects of alternative futures.

A. Output Projections

Future production levels and product mixes of the agricultural and silvicultural sectors are clearly based upon variables whose future values cannot be precisely determined. Thus, innumerable projections can be obtained by assuming various rates of growth for these variables. Since it was necessary to establish a firm baseline upon which the significance of the future environmental trends could be measured, known and generally accepted projections were utilized: ERS projections for 1985 (USDA, 76) and the OBERS projections for 2010 (USWRC, 1975). Inherent in the models on which these projections were based are assumptions concerning variables such as population, economic growth, technological advance, housing starts, and international trade. For reference, these assumptions are discussed further in section C, below. An additional assumption germane to the present study is that current environmental policies will remain constant through 2010.

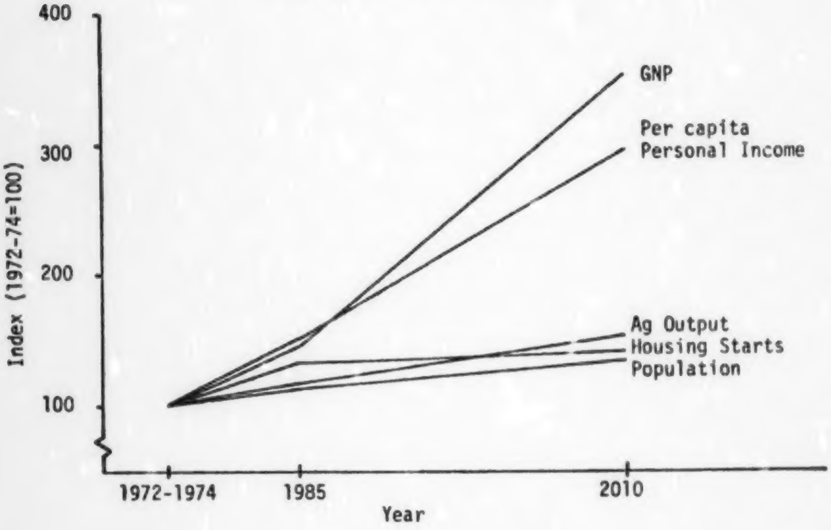
The ERS and OBERS projections of selected key variables are given numerically in Exhibit III-1 and graphically in Exhibit III-2. These projections reflect moderate rates of growth. Exhibit III-1 indicates that U.S. population is expected to increase from about 210 million in 1972-74 to 235 million in 1985 and 281 million in 2010. Estimates by the Bureau of the Census (Series E) assume a fertility level of 2,100 per 1000 women by 2005 and zero population growth levels by mid-century. The Gross National Product (total man hours employed x output per man hour) is expected to increase to $2,890 billion (1958 dollars) by 2010. This projection assumes that output per manhour will increase 2.9 percent annually and that total manhours worked will decrease at a rate of 0.35 percent per year. Housing starts, an indicator for the most important consuming sector of processed wood, will increase 40 percent over 1972-74 by 2010.

Per capita personal income, an alternative measure of economic growth, is expected to increase to $9,370 (1958 dollars) by 2010.

Exhibit III-1. Exogenous variables: Projections under moderate growth assumptions on population, per capita personal income, housing starts, and gross national product with current environmental controls

Variable	Unit	1972-74	Index (1972-74 = 100)		
			Current	1985	2010
Population	Million	210.4	100	111	134
Gross National Product	Billion of 1958 $	817.0	100	147	354
Per Capita Personal Income	1958 $	3,155.0	100	150	297
Housing Starts	Million	1.93	100	133	140
Agricultural Output Index	1967=100	110	100	118	151

Exhibit III-2. Exogenous variables: Graphical representation under moderate rates of growth



The trend in foreign demand is influenced by such variables as world population growth, production capacity, market conditions, and weather. Interruption in foreign demand caused by temporary fluctuations in foreign production levels make predictions difficult; however, it was generally felt that these disturbances would tend to show an upward bias from the permanent trend. In silviculture, imports and exports do not significantly affect U.S. supplies. The silviculture export variable is not as important in its effect upon production as is that for agriculture.

Agriculture and silviculture technological advancements defy precise measurements. They are expected to advance but at a slower rate than that which has occurred over the last two decades.

The baseline agriculture and silviculture production projections for 1985 and 2010 are given in Exhibit III-3. The 1967-based agricultural output index is projected to increase from 110 in 1972-74 to 130 and 166 in 1985 and 2010 respectively. Of the major grain crops, soybeans is expected to grow most dramatically to the year 2010, with growth projected at 228 percent from the 1972-74 average production of 1,350 million bushels. Corn (5,290 million bushels in 1972-74) and wheat (1,681 million bushels in 1972-74) are projected to grow 75 percent and 26 percent respectively over the same time period. Beef production will increase from 22,700 million pounds in 1972-74 to 39,600 million pounds in 2010, a growth of 75 percent. Pork will increase 49 percent in the same time period.

Timber, roundwood basis, is projected to increase by 119 percent to 25,200 million cubic feet by the year 2010. Pulpwood shows the most significant rate of growth, increasing from 3,800 cubic feet (1972-74) to 12,500 cubic feet (2010) which is a 229 percent growth.

B. Resource Availability

The availability of resources for agriculture and silviculture should not present a production constraint of any significance to the year 2010. Supplies of important minerals and chemicals used in the production of fertilizers and pesticides will be adequate. Neither energy nor land should constrain production to the year 2010.

The current and projected agricultural use of fertilziers, pesticides, cropland harvested, and energy are given in numeric form in Exhibit III-4 and graphically in Exhibit III-5. Total agricultural production will increase by 51 percent from 1972-74 to 2010. To achieve this level of production, the key inputs will also increase: nitrogen fertilizer will increase by 106 percent, pesticices by 118 percent, and energy by 10 percent. Harvested croplands will increase by 14 percent.

Exhibit III-3. Projections by commodity for selected years 1985 and 2010 under moderate growth assumptions

Commodity	Million units	72-74	1985	2010
Crops				
Wheat	bu.	1,681	1,764	2,109
Rye	bu.	24.9	40	51.4
Rice	cwt.	88	118	159
Corn for grain	bu.	5,290	6,618	9,271
Silage	tons	140 1/	146	174
Grain Sorghum	bu.	789	1,132	1,664
Oats	bu.	660	885	1,106
Barley	bu.	384	550	699
Fruits and nuts	lbs.	48,413 2/	48,795 2/	58,603
Vegetables	cwt.	49,457	56,745	70,416
Hay	tons	130	140	173
Soybeans	bu.	1,350	1,835	3,071
Flaxseed	bu.	14.4	28.0	23.9
Peanuts	lbs.	3,476	4,813	6,998
Cotton	bales	12.7	10.7	10.8
Sugarcane	tons	16.9	19.7	26.5
Sugarbeets	tons	25.1	33.6	43.2
Tobacco	lbs.	1,828	2,140	2,348
Irish & sweet potatoes	cwt.	324.8	367.9	446.1
Dry beans & peas	lbs.	2,167	2,234	2,245
Livestock				
Beef and veal	lbs.	22,669	30,051	39,563
Pork	lbs.	13,384	15,745	19,979
Lamb and mutton	lbs.	509	195	202
Chickens	lbs.	9,028	11,973	16,136
Turkeys	lbs.	2,569	2,639	3,727
Eggs	doz.	5,610	6,353	7,349
Milk	lbs.	1,169	1,211	1,273
Timber				
All roundwood	cu. ft.	11,525 3/	17,170	25,200
Sawlogs, veneer logs & other industrial products	cu. ft.	6,768 3/	10,000	12,100
Pulpwood	cu. ft.	3,800 3/	6,676	12,500
Farm output index 1967=100		110	130	166

1/ Production for 1971

2/ Citrus and non-citrus fruits only

3/ Preliminary

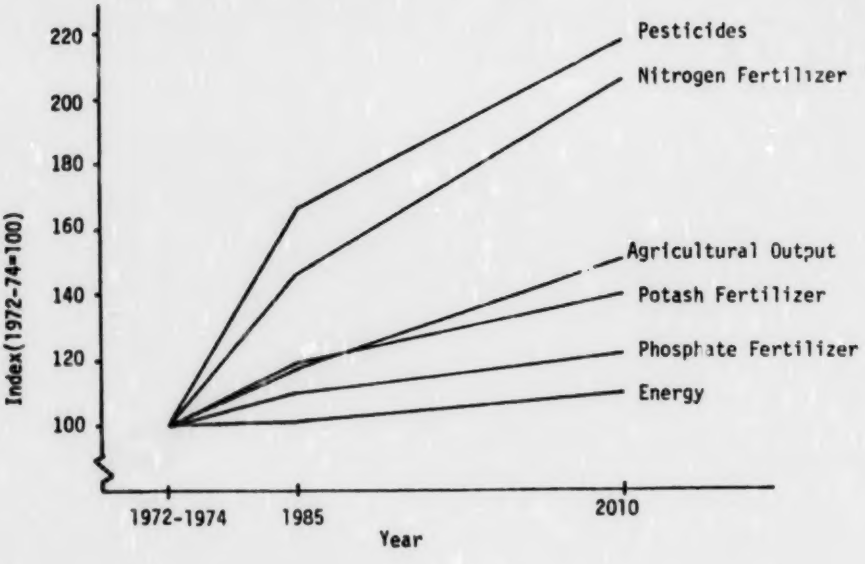
Source: ERS, Agriculture the Third Century, USDA, 1976. OBERS, 1972 OBERS Projections Supplement, U.S. Water Resources Council, 1975.

Exhibit III-4. Projections index for agricultural resources for selected years 1985 and 2010 under moderate growth assumptions

Variable	Unit	1972-74	Index (1972-74 = 100)		
			Current	1985	2010
Cropland Harvested	Million acres	311	100	102	114
Fertilizer					
Nitrogen (N)	Million of tons	8.2	100	146	206
Phosphates	Million of tons	5.0	100	110	122
Potash (k_2O)	Million of tons	4.7	100	119	140
Pesticides	Million lbs		100	166	218
Energy	Billion gals	8.0	100	101	110
Agricultural Output Index	1967=100	110	100	118	151

Sources: ERS, USDA estimates and DPRA projections

Exhibit III-5. Agricultural resources: Projections under moderate growth assumptions



Fertilizer and pesticide use in silviculture has been minimal, although under current projections, some 10.6 million acres of commercial forest land are eligible for potentially viable fertilizer treatment. Specific fertilizer use projections for forest growth vary widely and have not been projected by ERS or OBERS.

In 1972, 830,000 forest acres, significantly less than one percent of the commercial forest lands, received insecticide application. Since insecticides are used on an as-needed basis, their application fluctuates year by year and region by region. In 1972, 490,000 acres were treated with herbicides. At an application rate of 2.9 pounds per acre, the estimated annual consumption level was 710 tons.

An examination of Exhibit III-6 reveals that 400 million acres or 27.8 percent of the total U.S. acres are classified as cropland and 375 million acres or 26 percent are classified as forest. The 400 million acres of cropland includes idle cropland, summer fallow, and cropland harvested. With a projected cropland harvested in 2010 of 355 million acres, sufficient land presently considered "cropland" exists to meet demand under baseline conditions; however, if demand is significantly above the assumed level, 111 million additional acres of land considered "high" and "medium" in conversion potential are available for crop production (SCS, 1976).

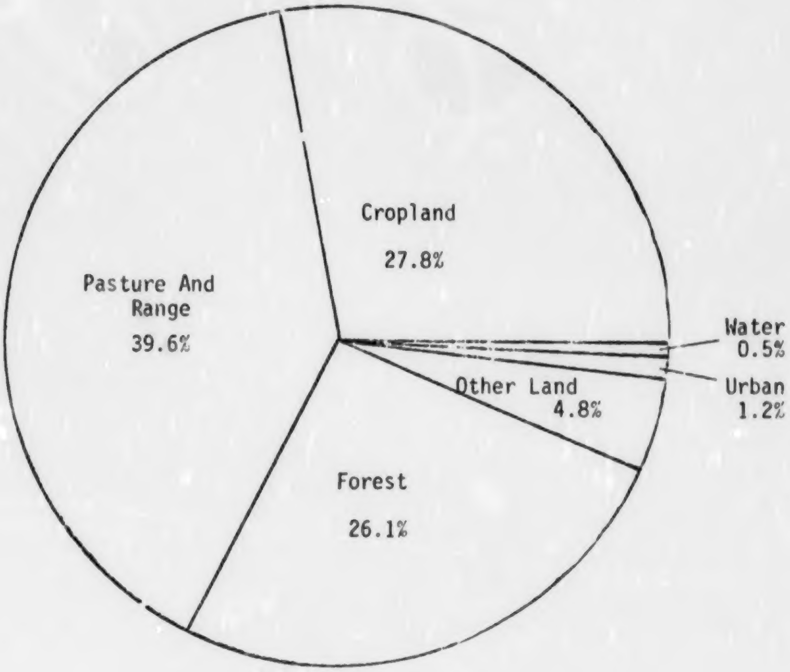
A breakdown in acres by potential category and development needed classification is given in Exhibit III-7 and a breakdown of current use is presented in Exhibit III-8. Of the 111 million acres, high and medium conversion potential land, 24 million acres would require only tillage to bring it into production. An additional 74 million acres would require efforts by individuals (e.g., removing stones or improved management techniques) to make production possible. This additional land will provide an ample reserve should demand warrant its use.

Forest lands are projected to decline by about 4 percent by 2010--a result of both reductions of and additions to "commercial" forest land. The forest lands in 2010 are also expected to be managed in a variety of ways ranging from the retention of stagnating old growth in the West to accelerated pulp rotations in the South.

C. General Assumptions

The OBERS projections are based on long run-secular criteria that adjust for the cyclical fluctuations which consistently characterize the shortrun path of the national economy. The general assumptions that underlie the projections are as follows:

Exhibit III-6. Distribution of U.S. land by use category (estimated acres) 1975



Use Category	Acres [1/]
Cropland	400,416,747
Pasture and Range	570,880,743
Forest	375,448,062
Other Land	69,830,326
Urban	16,635,613
Water	6,708,738
Total	1,439,920,229

[1/] Excludes Alaska and Hawaii

Source: United States Department of Agriculture, Soil Conservation Service, "Potential Cropland Study", Washington, D.C., 1976 (Preliminary).

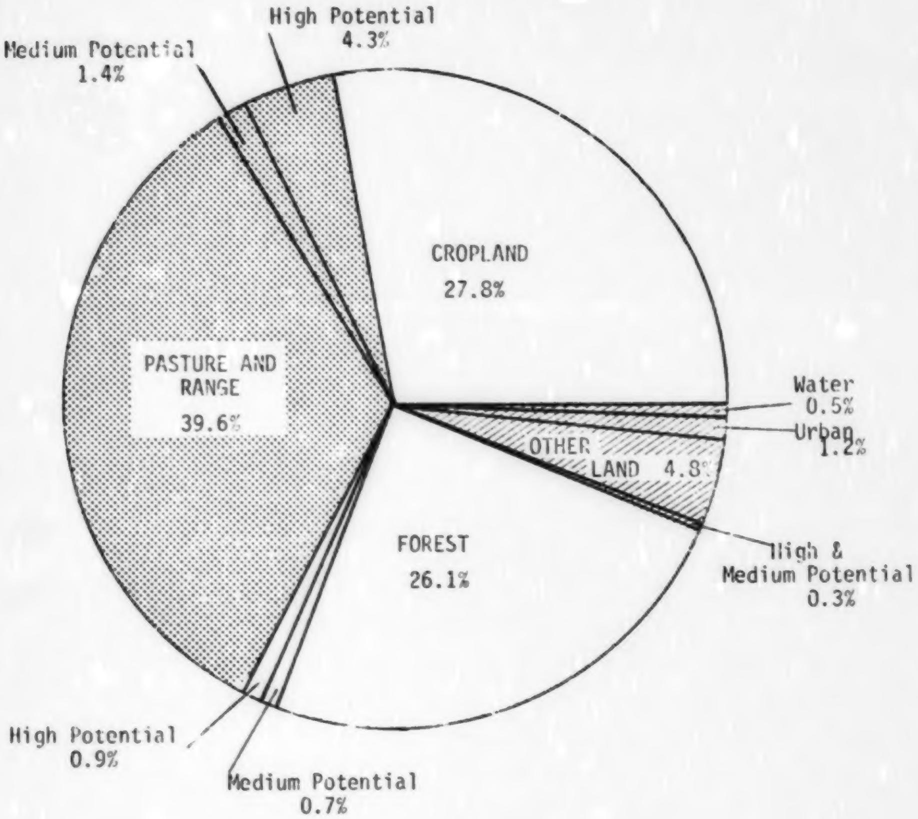
Exhibit III-7. Potential for cropland with development necessary by land uses (estimated acres) 1975 1/

	Development Necessary	High Potential (acres)	Medium Potential (acres)
Pasture and Range			
	None	30,794,671	4,894,499
	On-farm	23,301,705	13,846,315
	Multi-farm	1,091,440	734,150
	Project action	1,869,187	617,256
TOTAL		62,057,003	20,092,220
Forest			
	None	260,010	46,138
	On-farm	12,006,286	8,481,315
	Multi-farm	355,712	656,751
	Project action	719,583	1,683,521
TOTAL		13,341,591	10,867,725
Other Land			
	None	919,341	225,817
	On-farm	1,866,897	1,038,001
	Multi-farm	51,255	84,909
	Project-action	30,856	495,857
TOTAL		2,868,349	1,844,584

1/ Excludes Alaska and Hawaii

Source: United States Department of Agriculture, Soil Conservation Service, "Potential Cropland Study", Washington, D.C., 1976.

Exhibit III-8. Sources of "potential cropland" by current use (estimated acres) 1975 1/



Note: High and Medium Potential Cropland

Total Potential Cropland Acres = 111 million acres
Percent of Total Land = 7.7
Percent of 1975 Cropland = 27.7

1/ Excludes Alsaska and Hawaii

Source: United States Department of Agriculture, Soil Conservation Service, "Potential Cropland Study," Washington, D.C. 1976.

(1) Growth of population will be conditioned by a fertility rate which represents "replacement level fertility."

(2) Nationally, a "full employment" rate (includes 4 percent unemployment) will prevail at the points for which projections are made. As in the past, unemployment will be disproportionately distributed regionally, but the extent of disproportionality will diminish.

(3) The projections are assumed to be free of the immediate and direct effects of wars.

(4) Continued technological progress and capital accumulation will support a growth in private output per manhour of 2.9 percent annually.

(5) The new products that will appear will be accommodated within the existing industrial classification system, and therefore, no new industrial classifications are necessary.

(6) Growth in output can be achieved without ecological disaster or serious deterioration although diversion of resources for pollution control will cause changes in the industrial mix of output.

In dealing with projections, a margin of sensitivity should be considered. The projections given represent levels of production and utilization that would occur should the underlying assumptions hold. For example, the export demand component is not likely to follow a steady secular trend. It has been assumed that this variable will grow moderately, but the last few years has demonstrated that rapid increases in demand can occur as unexpected interruptions.

Food production is likely to vary seasonally due to the fluctuation of weather and climate. Unfortunately, current forecasts cannot produce reliable predictions of future conditions. Thus, it was necessary to assume normal weather with poor and above normal conditions averaged over time.

Current environmental standards have been assumed to remain intact throughout the projection period. Any signficant movement toward more stringent controls is likely to reduce agriculture production. Changes likely to be made under stringent controls would be, for example, the mandatory rather than the voluntary adoption of certain conservation practices, restrictions on use and formulation of fertilizers and banning of certain pesticides for all uses.

The development of regulations upon silviculture for environmental protection has been accelerating. While protecting the environment, these regulations are increasing costs of harvest and administration. It was assumed that despite additional costs, the rate of harvest will not be affected appreciably. In addition, the Forest Service has withdrawn areas in the West, especially in the Rocky Mountain Region for further study as wilderness areas. It was assumed that no further withdrawals of high-site commercial forest land will occur during the projection period.

Small private ownerships provided 49 percent of the nation's roundwood needs in 1970. By 2010 private holdings are expected to provide 57 percent of a total consumption figure that will have more than doubled. If this level of production is to be met, this private non-industrial sector must practice more intensive management. It was assumed that enough private forest land will come under management to provide the volumes projected.

D. Function of Moderate Growth Scenario

Doubtless, a scenario descriptive of long-term economic and technological conditions and developments is tentative at best. Problems attendant upon population, energy resources, world trade, and international social needs are not susceptible to quantifiable definition that a definitive long-term analysis would require. Too, the present technological sophistication of agriculture and silviculture -- their response to increasing mechanization, greatly varied and changing agronomical cultural practices, and an increasing reliance on constantly developing chemical and biological agents -- has resulted in a rapidly altering agro-technical science that precludes an invesigator's knowing with assurance what the future technological profiles of these economic sectors will be. Thus, though analysis be thorough and consistent, researchers must nevertheless recognize that best projections and assumptions cannot be ultimately descriptive of so varied and complex an entity as long-term food and fiber needs and scientific response to them.

Obviously, then this study's foregoing projections and assumptions, though based on the generally accepted ERS and OBERS models, remain suppositional. The study uses a moderate growth model, in part because moderate growth is a reasonable and measurable assumption, and in part, because such a projection does not necessitate the use of a highly distorted and most tentative set of assumptions concerning agri-science's technological development. It must be realized, also, that the assumption of a moderate growth model rather than a uniquely different one or even alternate sets of assumptions is consistent with the purpose of the study. The scope of the study does not envision the construction of indices attempting to quantify in precise terms the environmental impact of agricultural and silvicultural practices and inputs in either the short or the long term, for such indices would be but tentative. The rationale for the study, rather, is that it should seek to identify, classify, and rank in their order of magnitude the present and probable trends in agriculture and silviculture which will effect either beneficial or deleterious environmental change. To the extent reasonable, such trends and their consequent effects should, additionally, be ranked in relative order and be assigned terms indicative of the extensiveness and intensiveness of their effects upon the environment.

The overall relationships and the relative environmental effects of the various trends will not appreciably change under any but the most extreme scenario variations. To be sure, for instance, an extensive long term drought over a wide geographic area affecting a substantial portion of world population would create an export demand for agricultural products so encompassing that it would severely impact agricultural practices. The resulting need to employ marginally productive acreage and chemical and biological agents would be great enough to distort seriously the "normal" relationships among the applicable agricultural trends and their environmental effects. But though such a possibility may exist, its unpredictability and unknown specificity make it unreasonable to attempt a measurement of it. Such would be true of any extensive distortion of the generally accepted growth patterns incorporated in the ERS and OBERS projections used in the present study. Thus, the reader, in considering the foregoing scenario and its specific measurements, must recognize that the scenario is essentially a means to an end, a baseline projection by which the central purpose of this study is forwarded. Seen in this light, the study's use of a moderate growth pattern is both instrumental and reasonable.

SECTION IV

THE EVALUATION WORKSHOP

As mentioned previously (Section I: "Introduction") the Contractor's tentative analysis of the environmental effects of agricultural and silvicultural trends and management practices was submitted to an evaluation workshop for review and, where necessary, elaboration. Initially, the Contractor researched the study by examining pertinent economic and agriculture and silviculture data and by consulting with appropriate specialists in germane disciplines. This initial research resulted in a preliminary report which (1) defined acceptable resource and demand projections, (2) identified and categorized agricultural and silvicultural sectors, (3) classified and characterized the major production practices and trends in those sectors, (4) described currently available measurements of the environmental effects of those practices and trends, and (5) designed the evaluation procedures applicable to the examination of the study's preliminary findings. The report became the working document used by the evaluation workshop to assess the overall and the specific assumptions of the Contractor's preliminary findings. The preliminary report in large part is reflected in the present study in Sections I, II, and III, in the various Part C: "Background Summary" portions of Sections VI - X, and in the "Appendix B."

The present section briefly describes the evaluation workshop and its procedure and offers a general description of its participants.

A. The Evaluation Workshop

Under the sponsorship of the U.S. Environmental Protection Agency (EPA) and its Environmental Research Laboratory, Athens, Georgia, an Evaluation Workshop was held February 1-4, 1977 in Athens, Georgia to assess the environmental implications of selected key trends in agriculture and silviculture. These selected trends were defined prior to the workshop in the preliminary report which was prepared as a working document for the workshop by Development Planning and Research Associates, Inc. and the Tuolumne Corporation.

During the workshop, a single "scenario" of moderate growth rates in the general economy, including agriculture and silviculture, was assessed from 1976 to 2010, i.e., basically the OBERS E' projections to 2010. Both higher and lower demand cases were perceived as plausible, but the limited time for the workshop necessitated that only the moderate case be evaluated.

The workshop participants evaluated the environmental significance of principal environmentally related trends and developments in agriculture and silviculture as identified by the Contractor. Moreover, the workshop participants were free to modify, re-group and/or add or delete trends as they deemed appropriate. Their evaluations included judgments of both the short-term and long-term significance of the selected trends and developments, but the primary focus of the workshop was on the long-term future, i.e., 2010.

Two types of rankings of trends were determined by the Workshop. First, rankings of the major trends in each of five panel areas were determined by each respective panel, i.e.,

Agriculture

Panel 1: Nonirrigated Crop Production
Panel 2: Irrigated Crop Production
Panel 3: Feedlot Production
Panel 4: Range and Pasture Management

Silviculture

Panel 5: Silviculture and Harvest Management

In particular, each panel identified the ten most significant environmentally related trends (whether beneficial, adverse or both) in their own panel area.

Second, the five most important trends from each panel were assessed and ranked by the workshop participants collectively. (Subsequently, during the workshop, agriculture and silviculture trend rankings were independently grouped as explained below.) Caution is advised when interpreting the overall agriculture trend rankings since some panel trends (ranked 6 to 10, for example) may justifiably have been among the major twenty if the Workshop procedures had permitted more than five trends from any one panel to have been evaluated in the overall rankings. In other words, although 20 major trends from four agriculture panels (5 trends from each) were ranked, these trends are not necessarily the 20 most significant environmentally related trends in agriculture.

B. Workshop Procedures

The evaluation workshop consisted of an alternating series of general sessions and individual panel sessions as indicated in the Workshop Agenda, Exhibit IV-1. The proceedings were so structured that specific forms were to be completed at each panel session and results summarized at the general sessions. The eight forms that were utilized are included in the Appendix.

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Exhibit IV-1. Environmental implications of trends in agriculture and silviculture

WORKSHOP AGENDA 1/

AGENDA	TIME	ACTIVITY
TUESDAY - FEB. 1 REGISTRATION	8:00 p.m.	. Arrive from Atlanta (Charter Bus) . Light buffet supper . Registration and informal discussion
WEDNESDAY - FEB. 2 BREAKFAST	7:15 a.m.	. Group breakfast (designated dining area)
	8:00 a.m.	. Registration (late arrivals)
GENERAL SESSION I	8:30 a.m.	. Opening remarks - George Bailey, EPA . Introduction of Participants - Ray Seltzer, DPRA . Welcome . Henry Garren, Dean of Agric., U.of Ga. . David Duttweilar, Director of Environmental Research Laboratory, Athens, Ga. . Overview of agriculture and silviculture: 1976-2010 - Sam Unger, DPRA and Pete Arnold, Tuolumne . Briefing on workshop procedures - Gary Davis, DPRA
	10:30 a.m.	. Break
PANEL SESSIONS I	11:00 a.m.	. Five panels meet separately (designated areas) . Chairman leads - EPA and Contractor are resource people only . Begin Form 1 - Extensiveness values
LUNCH	12:00 p.m.	. Group lunch (designated dining area)
PANEL SESSIONS II	1:00 p.m.	. Complete Form 1 (before break) . Begin Form 2 - Intensiveness values
	3:00 p.m.	. Break
	3:30 p.m.	. Complete Form 2 (before adjournment if possible)
	5:00 p.m.	. Adjour panel sessions
DINNER	6:00 - 7:00 p.m.	. Group dinner (designated area)
PANEL SESSIONS III	7:30 p.m.	. Complete Form 3 - Environmental implications ratings and adjusted ratings . Determine top 5 and second most important 5 environmentally related trends . Complete Form 4 - Summary of ratings and rationale . Chairman outline panel presentation
	9:30 p.m.	. Adjourn . Submit panel's Form 4 to DPRA representative . DPRA prepare all panel summaries for subsequent distribution

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Exhibit IV-1 (continued)

AGENDA	TIME	ACTIVITY
THURSDAY - FEB. 3		
BREAKFAST	7:15 a.m.	Group breakfast (designated dining area)
GENERAL SESSION II	8:30 a.m.	. Distribute panel rating summaries (top 5, plus next 5) . Panel chairmen present top trends . Discussion of each panel's results
	10:00 a.m.	. Break
	10:30 a.m.	. Continue panel rating summaries and discussions
LUNCH	12:00 p.m.	. Group lunch (designated dining area)
GENERAL SESSION III	1:00 p.m.	. Finish panel rating summaries and discussion (prior to break if possible)
	2:30 p.m.	. Break
PANEL SESSION IV	3:00 p.m.	. Each panel rank 25 major trends (top 5 from each panel) . Complete Form 5 . Chairman outline panel presentation
	5:00 p.m.	. Adjourn . Submit panel's Form 5 to DPRA representative . DPRA summarize panel findings on Form 6
DINNER	6:30 - 9:30	. Dinner banquet (Charlie Williams' Pinecrest Lodges) . Transportation provided per instructions
FRIDAY - FEB. 4		
BREAKFAST	7:15 a.m.	. Group breakfast (designated dining area)
GENERAL SESSION IV	8:30 a.m.	. DPRA present summary of all panel's rankings - Form 6 . Panel chairmen present rationale for panel's rankings . Limited discussion
	10:00 a.m.	. Break
	10:30 a.m.	. Each participant rank 25 major trends independent of panel - Form 7 . Each participant add trends from his panel which should be in top 25 (from trends 6 to 10 only) - Form 8
	11:00 a.m.	. Workshop Wrap-Up . Ray Seltzer, DPRA . Pierre Crosson, RFF . George Bailey, EPA
	11:30 a.m.	Adjourn
LUNCH	11:45 a.m.	Group lunch
	12:00 p.m.	Air transport bus arrives for loading
	1:00 p.m.	Bus leaves for Atlanta (Estimated arrival at 3:00 p.m.)

These procedures were discussed in the report which was distributed to the workshop participants prior to the meeting and again during the first General Session of the workshop.

The evaluation procedure also involved the use of a rating system as is explained in Exhibit IV-2. Each trend (or prospective development) was rated in relative terms for both its "extensiveness of use" and "intensiveness of effect" to yield a multiplicative rating:

$$\begin{array}{l} \text{Environmental} \\ \text{Implications} \\ \text{Rating} \end{array} = \begin{array}{l} \text{Extensiveness of Use X} \\ \text{Intensiveness of Effect} \end{array}$$

or,

$$R = E \times I,$$

as defined in Exhibit IV-2. This rating procedure was used within each panel to establish relative ratings among the trends (subtrends). These ratings were then used as the basis for ranking trends within each panel. The "intensiveness of effect" rating, (I), should be noted in particular. By definition, for the workshop, a trend could have either a beneficial (+) effect or an adverse (-) effect on the environment in 2010 compared to its effect in the current period (1976). It was also possible for a trend (subtrend) to have both beneficial and adverse effects upon the environment. For example, conservation tillage would reduce soil erosion, but generally require increased pesticide usage.

The extensiveness (E) and intensiveness (I) ratings *within panels* were applied to subtrends within trends, rather than the overall trend, *per se*. That is, as shown within each panel summary, trends are usually comprised of two or more components. These components identify much more specific management practices or developments (including emerging technological developments which are projected to be important by 2010). Hence, a "trend" in this analysis is generally a cluster of subtrends, and the reader is advised to assess the component parts to better understand the meaning of the trend. (In fact, some trend labels appear as "problems" not as "trends." However, by assessing the subtrends, the proper interpretation can be made of the trend. This topic is discussed further in Section V, below.)

The panels of experts were permitted, furthermore, to adjust their environmental implications rating, R, following their initial assessments of each trend. This adjusted rating, AR, best reflects each panels'

Exhibit IV-2. Rating system definition for the assessment of environment implications of trends in agriculture and silviculture

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Environmental Rating	=	Extensiveness of Use	x	Intensiveness of Effect
R	=	(E)	x	(I)
±(1-25)		(1-5)		± (1-5) [1/]

where,

Rating: R = An index of the overall environmental significance of a trend or development in terms of both the scope of the trend (E) and the seriousness of the environmental implications (I) of the trend. R is the product of the ratings for E (1 to 5) and for I (± 1 to 5) as defined below.

Factor 1: E = Extensiveness of use of the trend (current or projected). Criteria shall include:

(1) geographic scope (national vs local)
(2) degree to which total acreage or sector ouput of the nation is impacted
(3) Other (define)

A rating of 1 to 5 shall be qualitatively and subjectively determined for each trend or development as follows:

Rating Scale		Description
1	-	minor significance
2	-	(limited)
3	-	moderate significance
4	-	(important)
5	-	major significance

Factor 2: I = Intensiveness of effect of the trend (including its persistence and potential irreversibility of effect). Criteria shall include:

(1) human health effects
(2) ecological system disruptions
(3) wildlife and wildlife habitat effects
(4) recreation effects
(5) aesthetic consequences
(6) yields, production, and associated effects
(7) other (define)

A rating of ±(1-5) shall be qualitatively and subjectively determined for each "unit" of production to which the trend or development applies, i.e., irrespective of scope of the trend. A plus(+) rating denotes a positive or beneficial effect on the environment (on balance); whereas, a negative (-) rating denotes a negative or adverse effect on the environment (on balance). The ratings shall be as follows:

Rating Scale		Description
(+ or -) 1	-	minor significance
(+ or -) 2	-	(limited)
(+ or -) 3	-	moderate significance
(+ or -) 4	-	(important)
(+ or -) 5	-	major significance

(+) = beneficial, (-) = adverse

Each factor shall be rated on a scale from 1 to 5 (E has positive values only whereas I may be either positive or negative, representing beneficial or adverse environmental effects, respectively). These factors, when multiplied, may yield an environmental rating, R, from ± (1 to 25). Relatively high absolute ratings will denote the most important environmentally related trends, whereas relatively low absolute scores will denote the less significant environmentally related trends. The sign of the rating plus (+) or minus (-) will denote whether the trend is either beneficial or adverse on an aggregate basis. Special remarks should accompany this overall rating in the case of conflicting/offsetting beneficial and adverse environmental components to explain the resolution of the conflict.

[1/] Each selected trend or development in agriculture and silviculture is to be judged based on the rating scales as defined. Relative ratings, R, across trends provides a common basis for qualitatively ranking major environmentally related trends in agriculture and silviculture.

value judgements of the relative significance of each trend's environmental implications by 2010. As is explained in the discussion of the panel sections below, each panel utilized the rating system somewhat differently to arrive at its judgements of the leading trends that will have associated environmental effects. [1]

In most instances, the panels would have preferred to have regionalized their results, subdivided their area into more specific production segments, and taken more time to assess the temporal dimensions of the problem. Nevertheless, the final rankings by each panel at the national level were determined with generally firm agreement as to the trends' relative importance vis-a-vis environmental change from the current period (beneficial and/or adverse).

After the rankings within panels, each panel submitted its five top trends to the entire workshop in general session for review and discussion. The participants then returned to panel sessions to determine a combined ranking of all of the panel's leading five trends. As is explained below, in the final ranking, the trends of agriculture were separated from the trends of silviculture, resulting in a ranking from 1 to 20 of the major trends from agriculture, and a ranking from 1 to 5 of the major trends from silviculture. Finally, upon completion of the workshop rankings, each participant was also given the opportunity to rank the trends independent of his panel.

C. Participants

A total of twenty-six participants from throughout the United States were involved in the evaluation workshop. These participants were selected to serve on the specific panel which considered their individual areas of professional expertise.

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[1] Criteria used in reaching extensiveness of use and intensiveness of effect ratings are shown in Exhibit IV-2. Note is made of the sixth criterion for intensiveness ratings: yields, production, and associated effects. While the other criteria deal with direct and indirect environmental implications, this criterion deals with productivity, (an indirect environmental effect given a specified demand level) and caused some concern within the panels when incorporating this into intensiveness values. Consequently improper emphasis may have been given to this criterion when assessing trends (subtrends) dealing directly with "practices," but this criterion was important when evaluating the intensiveness that many "development" subtrends would have on the environment in 2010. However, since panels were allowed to adjust their ratings (R) to reflect value judgements, this allowed for the desired perspective for intensiveness ratings.

All geographic regions of the U.S., and many disciplines within agriculture, silviculture and environmental science were represented by the participants. Also, representatives of government (federal and state), universities (including extension) and private industry were involved. Naturally, the workshop as a whole was more broadly representative than were individual panels. An effort was made within the size constraints of the workshop, to provide adequate expertise on each panel to effectively complete the evaluations. However, for example, the Irrigated Crop Production Panel did not have a pesticide expert; and, consequently, they did not evaluate the pest control trends, per se (the panel basically referred this assessment to the Nonirrigated Crop Production Panel--which did have pesticide and pest control expertise). Aside from this type of specific limitation, the panels were generally balanced across disciplines needed for the assessment.

Each panel's participants are identified below in the panel summary discussions.

SECTION V

THE LEADING ENVIRONMENTALLY-RELATED TRENDS: AGRICULTURE AND SILVICULTURE

This brief section is intended only to offer the reader a generalized ranking of each agricultural and silvicultural panel's leading environmentally-related trends in the major sectors considered in this study. The trends are not considered at length at this point. Such discussions are considered in Sections VI-X which are devoted to the five panel areas. The present discussion is but an introductory overview partially indicative of the findings of each panel.

An important aspect of this study's assessment of the environmental implications of trends in agriculture and silviculture is the "level-of-aggregation" of the study. In reality, the sources of residuals (and pollutants) in the environment are usually individual production management practices throughout the agriculture and silviculture sectors. However, it was not feasible to consider all specific management practices within each segment of agriculture and silviculture in this study.

The approach of this assessment involved, first, the subdivision of these sectors into five distinct production systems; and, second, the partitioning of management practices and developments within each production system into major groupings. Thirdly, key management practices and developments within each management grouping were delineated and described. Finally, available environmentally-related information (mostly qualitative at this time) was included for each of the selected key trends and developments.

As discussed in Section IV, each of the panels examined the preliminary study done by DPRA and its own subject area. Each panel then submitted its area's five trends for general review and discussion. These leading panel trends are summarized in Exhibit V-1.

The major trends and developments within each panel area are quite diversified and often unique to a specific panel area. Consequently, Development Planning and Research Associates believed that each panel area required focused attention if the major environmentally related trends of agriculture and silviculture were to be comprehensively understood.

Also shown in Exhibit V-1 are each panel's "adjusted ratings" of the relative environmental significance of each trend within the respective panel areas (scores ranging from 1 to 25 were possible as explained in

Exhibit V-1. Summary of panel and workshop rankings of major trends in agriculture and silviculture, 1976-2010

Panel	Trend No. 2/	Trend	Initial Panel Rank of Top Five Trends	Panel Adjusted Rating (AR)	Final Workshop Rank of Trends
1. Nonirrigated Crop Production	(104)	Runoff & Erosion Control	1	18	1
	(119)	Improvement of Seeds & Plants (103 + 114)	2	16	5
	(101)	Conservation Tillage	3	14	2
	(120)	Scouting & Integrated Controls (112 + 117)	4	13	6
	(121)	Developing New Biological and Chemical Pesticides (115 + 116)	5	12	7
2. Irrigated Crop Production	(208)	Improving Water Application	1	22	3
	(204)	Runoff & Erosion Control	2	18	4
	(211)	Methods of Nutrient Application	3	15	11
	(220)	Developing Integrated Controls	4	12	14
	(210)	Using Plant & Soil Analysis	5	9	16
3. Feedlot Production	(308)	Feedlot Size	1	15	9
	(319)	Feedlot Design for Waste Management (306 + 311 + 312)	2	12	8
	(317)	Residual Disposal (312 + 315)	3	10	10
	(313)	Odor Control	4	9	17
	(318)	Feed Efficiency & Ration (302 + 305)	5	8	19
4. Range & Pasture Management	(406)	Grazing Practices: Range & Pasture	1	8	12
	(405)	Stocking Ranges	2	7	13
	(401)	Range & Pasture Renovation	3	6	15
	(416)	Using Increased Resources (411 + 415)	4	5	18
	(417)	Range & Pasture Improvement (402 + 404 + 407)	5	5	20
5. Silviculture and 1/ Harvest Management	(502)	Access to Timber Resource (Woods)	1	4	
	(505)	Site Preparation	2	4	
	(503)	Log Extraction	3	3	
	(504)	Utilization (Logs & Residues)	4	2	
	(510)	Fire Control	5	2	

1/ Silviculture trends were rated by the silviculture panel only and were not included in overall workshop rankings.

2/ The number reflects those trend numbers used in Phase I- Interim Report

Section IV, above). These ratings are not strictly comparable across panels, for each panel evaluated its trends independently.

Furthermore, extreme care must be emphasized when interpretations of, or conclusions about the trend ratings are made. First of all, the environmental trend ratings are numerical scores which quantify the opinions of selected professional agriculturalists who have specific knowledge about their panel areas. The most important distinction which must be recognized by environmentalists, agriculturalists, and any others who may desire to interpret these environmental ratings is that these ratings indicate only how important certain trends in agriculture and silviculture will be, in regards to improving or degrading the environment. The ratings only indicate how a certain practice can potentially change an environment from its current status.

In an attempt to clarify the distinction between trend ratings and environmental problems, the following example was constructed. If a particular trend had a rating of +20, this rating implies that the trend would be expected to improve the environment in a relatively important manner. The rating (+20) does not mean that the particular trend will eliminate environmental problems; rather it merely means that the trend is a relatively important activity which is expected to preserve (or improve) an environment's quality. It also does not imply that an environment is currently "good" or "bad".

Notwithstanding the individual panel's results, the workshop did continue to evaluate the relative importance of the top five trends from each panel. In the end, only the agriculture trends were cross-ranked, i.e., from 1 to 20, representing the four agricultural panels. It was determined that cross-ranking of trends in silviculture with those of agriculture was not feasible because of difficulties in comparing the two. Silviculture involves management over a long growth cycle, e.g., 30 to 60 years or more while agriculture comprises relatively intense management on an annual basis. Consequently, silviculture trends were listed separately. Ideally, much more quantitative information of environmental effects should be gathered before explicit rankings of trends are made. The workshop generally agreed that the Silviculture and Harvest Management trends would most likely rank in the lower half of the major twenty-five trends. This judgement was secondary, however, to the desire and concern of the workshop--especially the Silviculture Panel, to first recognize fundamental differences between agriculture and silviculture.

The data upon which each panel's judgements were made were those provided by DPRA in its economic scenario projections, the agricultural and silvicultural practices and input trend data compiled by DPRA and included in subsequent panel-area sections of the present study, and the individual knowledge and expertise of the panel participants.

The results of the overall ranking of the agriculture trends are discussed below in Section XI following the summarization of each panel's trends and ratings. For summary purposes, however, the final rankings of each panels trends are also shown in Exhibit V-1, but without further explanation here.

SECTION VI

ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 1 - NONIRRIGATED CROP PRODUCTION

The primary purpose of the Nonirrigated Crop Production Panel, as with other subsector panels, was to assess and rank-order the major environmentally related trends in its own area of expertise. The Panel 1 trends assessed, and their rankings, are as shown in Exhibit VI-1. Brief descriptions of the ten most significant trends are presented in Exhibit VI-2 (and in greater detail in subsection C, below). Additionally, the panel members assessed both the extensiveness of use and the intensiveness of environmental effects of each trend or practice, which are summarized in Exhibit VI-3; and, therefrom, the rankings were derived.

The Nonirrigated Crop Production Panel was the largest in the workshop and included the eight members listed below. The panelists represented a broad area of expertise: agronomy, pesticides, economics, fertilizers, erosion, management systems, and soil erosion and runoff. The chairman of the panel was George Browning, Regional Director of State Agriculture Experiment Stations, Iowa State University.

Name	Representing	Specialty	Location
George Browning	USDA-CSRS	Management systems	Ames, Iowa
W. L. Colville	University of Geo.	Crop production	Athens, Georgia
Velmar Davis	USDA-ERS	Economics	Washington, D.C.
Victor Kilmer	TVA	Fertilizer	Muscle Shoals, Ala.
R. L. Leonard	USDA-ARS	Pesticides	Athens, Georgia
Gary Margheim	USDA-SCS	Erosion	Washington, D.C.
Walt Wischmeier	Consultant	Erosion	West Lafayette, Ind.
Pierre Crosson	RFF	Economics	Washington, D. C.

A. Major Trend Rankings and Practices Assessments

As discussed previously (Section IV, "Workshop Procedures") the procedure used by the panel in assessing trends involved an analysis of the extensiveness (E) and intensiveness of effect (I) of each of the subtrends. The product of these two ratings gave a significance rating for the subtrend. Based on an examination of the ratings of all of the subtrends, a composite rating was assigned to each major trend. The final step in ranking the trends was an evaluation of all of the trends and a subsequent adjustment of the ratings in order to reflect a proper weighting among the trends (Exhibit VI-1). In this step, six ratings were adjusted with the greatest adjustment being made in the rating of Runoff and Erosion Control (104). This trend was initially assigned a rating (R) of nine. After the panel considered the impact of this trend in light of the impact of all other trends, it doubled the rating to eighteen.

Exhibit VI-1. Ranking of environmentally-related trends, 1976-2010: Nonirrigated Crop Production

Panel Rank	Trend Number	Trend 1/	Adjusted Rating
1	(104)	Runoff & erosion control	18
2	(119)	Improvement of seed and plants	16
3	(101)	Conservation tillage	14
4	(120)	Using scouting & integrated controls	13
5	(121)	Developing new biological & chemical pesticides	12
6	(107)	Improving soil-plant analysis	10
7	(108)	Methods of nutrient applying	8
8	(106)	Wind erosion control	8
9	(110)	Developing nitrogen-fixation sources	8
10	(113)	Improving pesticide application methods and timing	7
11	(111)	Developing improved fertilizer	6
12	(102)	Crop sequencing	4
13	(105)	Moisture conserving	2
14	(109)	Alternative nutrient sources	2
15	(118)	Using increasing rates and amounts of crop production inputs	1

1/ The panel specifically ranked the top ten trends as shown. Trends 11-15 were ranked by DPRA according to the intensiveness and extensiveness ratings associated by the panel.

Exhibit VI-2. Description of major environmentally-related trends, 1976-2010: Nonirrigated Crop Production

Panel Rank	Trend Number and Title	Adjusted Rating for 2010	Comments and Modifications
1	(104) Runoff and Erosion Control	18	Runoff and erosion control measures stabilize the soil impeding sediment movement and nutrient and pesticide runoff. The primary effect of these measures will be the reduction of water and land pollution; the secondary effect will be the increase of moisture retained in the soil and percolated.
2	(119) Improvement of Seed and Plants	16	These improvements include increases in production efficiency and increases in resistance to weather, insects, disease and other pests. These increases are expected to increase crop yields and decrease the overall requirements for pesticides.
3	(101) Conservation Tillage	14	Conservation tillage includes no-till and other practices involving a reduction in tillage over conventional systems. The increasing utilization of these practices will have major effects on water and soil quality by the reduction of runoff and soil movement.
4	(120) Using Scouting and Integrated Controls	13	Scouting, which involves both surface means and remote sensing, is expected to reduce the overall pesticide use by reducing requirements for continued application in areas having no threat of pest infestation. Integration of biological, chemical, and mechanical methods will increase the efficiency of pest control and decrease the overall pesticide requirements.
5	(121) Developing New Biological and Chemical Pesticides	12	Developments in new pesticide formulations and biological controls are expected to increase the efficiency of pest control.
6	(107) Improving Soil-Plant Analysis	10	New soil-plant analysis techniques for analyzing nutrient requirements are being developed which are expected to receive widespread application and will benefit both crop yield and the environment.
7	(108) Methods of Nutrient Applying	8	Methods are being developed and utilized which increases the efficiency of commercial fertilizer application. Generally, these methods have beneficial effects by increasing crop yield and reducing fertilizer runoff.
8	(106) Wind Erosion Control	8	The control measures, which include strip-cropping, barrier rows, and tree windbreaks, stabilize the soil and impede sediment movement.
9	(110) Developing Nitrogen-Fixation Sources	8	Developments in biological nitrogen-fixation, both in legumes and non-legumes, are expected to significantly decrease commercial fertilizer use.
10	(113) Improving Pesticide Application Methods and Timing	7	Improvements in methods of applying pesticides, such as dual application and improved placement, are occurring which will improve the efficiency of pesticide use and reduce the potential for pesticide runoff.

Exhibit VI-3. Environmental ratings of top ten trends and associated practices: Nonirrigated Production

Panel Rank	Trend Number	Trend and Subtrend	Extensiveness Trend Rating			Intensiveness Rating
			1976	1985	2010	2010
1	(104)	Runoff & Erosion Control				
		a. Contour farming or contour strip-cropping	3	4	5	+4
		b. Terraces and grass waterways	4	5	5	+4
		c. Optimizing time of operations	3	4	4	+4
		d. Narrow rows	3	4	5	+3
2	(119)	Improvement of Seed and Plants				
		a. Weather resistance	4	4	5	+2
		b. Salt resistance	1	1	1	+2
		c. Production efficiency	4	4	5	+3
		d. Disease resistant crops	5	5	5	+3
		e. Insect & nematode resistant crops	3	4	5	+3
3	(101)	Conservation Tillage				
		a. No-tillage	1	1	2	+4
		b. Reduced tillage	3	4	5	+3
4	(120)	Using Scouting and Integrated Controls				
		a. Surface scouting	1	3	5	+4
		b. Remote sensing scouting	1	1	2	+1
		c. Using integrated controls	2	3	4	+4
5	(121)	Developing New Biological and Chemical Pesticides				
		a. Micro-encapsulated pesticides	1	2	3	+2
		b. Systemic pesticides	2	3	4	+3
		c. Surfactants for herbicides	1	2	3	+2
		d. Bio-degradable pesticides	3	4	5	+4
		e. Alternative formulations	3	4	5	+2
		f. Juvenile hormones	1	2	4	+3
		g. Pheromones	1	2	4	+3
		h. Sterile males	1	1	2	+4
		i. Predator and parasites	1	1	1	+2
6	(107)	Improving Soil-Plant Analysis	3	4	5	+3
7	(108)	Methods of Nutrient Applying				
		a. Foliar fertilization	1	2	2	+1
		b. Multiple applications	3	3	4	+2
		c. Fall application	3	3	4	-2
		d. Liquid fertilizers	3	4	5	+1
		e. Aerial and floater application	1	1	2	-1
		f. Improved nutrient placement	4	4	4	+3
8	(106)	Wind Erosion Control				
		a. Strip-cropping	2	2	3	+3
		b. Barrier row	1	1	3	+3
		c. Windbreaks	1	1	2	+3
9	(110)	Developing Nitrogen-Fixation Sources				
		a. Legume sources	2	3	4	+2
		b. Non-legume sources	1	1	3	+3
10	(113)	Improving Pesticide Application Methods and Timing				
		a. Improving aerial application	3	4	4	+1
		b. Improving floater application	1	1	2	+1
		c. Fertilizer and pesticide dual application	3	4	4	+1
		d. Improving pesticide placement	2	3	4	+3

B. Environmental Implications of Major Trends and Practices

The workshop findings for each major trend are summarized below. Background descriptions and definitions of each of these major trends and the associated practices (or subtrends) are included in Part C: "Background Summary."

Runoff and Erosion Control (104). The panel rated this trend as the most significant environmentally rated trend based on the environmental implications expected from the individual subtrends which included contour farming, terracing, optimizing time of operations, and the use of narrow rows. Of these subtrends, contour farming and terracing were considered to have the greatest potential implications. The former subtrend received a 1976 extensiveness rating of moderate, while the latter received a rating of important. The extensiveness of both were expected to increase to a major level by 2010. The intensiveness of each was expected to be important (beneficial) by 2010. The panel observed that the trend in the use of narrow rows was increasing rapidly. Its 1976 extensiveness rating was moderate; however, this was expected to increase to a major level by 2010. The environmental implications were considered to be overall beneficial with a moderate rating. In extensiveness, optimizing time of operations received a moderate rating for 1976; it was expected to become important by 2010. In intensiveness, this subtrend was expected to have an important beneficial effect by 2010.

Improvement and Seed Plants (119). This trend was developed by the panel by combining two separate trends contained in the preliminary report (Seed/Plant Improving (103) and Developing Resistant Crops (114). */ In this trend the panel found difficulty in defining the research interaction between subtrends, though it did conclude that this major trend could have as much economic potential as any of the trends examined, particularly so in the case of developing disease resistant crops. The intensiveness of all of the subtrends was expected to be beneficial. The most extensive subtrend was considered by the panel to be the development of disease resistant crops. Its extensiveness in 1976 was considered to be major and was expected to continue so to 2010. The trends in production efficiency were considered to increase from a 1976 rating important to a level of major impo-tance by 2010. Trends in insect and nematode resistant crops were expected to increase from moderate to major importance by 2010. All three of the above subtrends were expected to have a moderate intensiveness by 2010. The intensiveness of the remaining two trends, weather resistance and salt resistance, were expected to result in only limited benefits to the environment. In extensiveness, improvements in weather resistance were expected to be major in 2010; improvements in salt resistance were expected to be minor through 2010.

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*/ See Part C: "Background Summary" for details of original trend descriptions.

Conservation tillage (101). No tillage and reduced tillage were expected to have significant environment implications because of their reduction of soil movement and run-off. However, the panel expressed the concern that the required increase in pesticide and fertilizer application would have adverse effects. Because of the increased fertilization and reduced run-off, the nitrate content of the groundwater could be expected to increase. Although the practice of reduced tillage and no-till both were considered to have substantial implications, beneficial on the environment ,moderate intensiveness for reduced tillage and important for no-tillage), the expected extensiveness varied considerably between the two. The 1976 extensiveness was rated as minor for no tillage and was expected to be only limited by 2010. On the other hand, the extensiveness of reduced tillage in 1976 was considered to be moderate and was expected to increase to major by 2010.

Using Scouting and Integrated Controls (120). This trend represents a combination of two separate trends contained in the preliminary report (Using Scouting (112) and Developing Integrated Controls (117). The trend was expected to have significant beneficial implications for the environment because of its resultant overall reduction in pesticide use. The subtrends include surface scouting, remote sensing scouting, and integrated controls use. Remote sensing was expected to have the least environmental implication both in extensiveness and intensiveness. Its extensiveness was rated as minor for 1976 and was not expected to increase significantly, becoming of only limited importance by 2010. Its intensiveness implication was considered by the panel to be minor. On the other hand, the intensiveness of both of the other subtrends was rated as major. Surface sensing was considered to have only a minor extensiveness in 1976 but a major extensiveness by 2010. Using integrated controls was rated limited in extensiveness for 1976 but was expected to increase to important by 2010.

Developing New Biological and Chemical Pesticides (121). This trend was developed by the panel by integrating two separate trends contained in the preliminary report, Developing New Pesticides (115) and Developing Biological Controls (116). The panel felt that all of the subtrends involving both chemical and biological pesticides would have overall beneficial implications. According to the panel, biological controls can generally be expected to replace chemical pesticides if anticipated breakthroughs occur. However, the panel felt the extensiveness of the subtrends associated with chemical pesticides would be somewhat greater than those with biological controls. The subtrends with the greatest extensiveness (major) were the development of biodegradable pesticides and use of alternative formulations; both were rated as moderate for 1976 and were expected to be major by 2010. In intensiveness, the environmental implications of the use of bio-degradable pesticides was the greatest, receiving a rating of important while that of the use of alternative formulations received a rating of limited. The panel felt that, assuming breakthroughs, the use of juvenile hormones and pheromones would become the most widespread of biological controls. Although both were rated as minor in extensiveness for 1976, they received a rating of important for 2010. The intensiveness for both trends was moderate. The use of sterile males received the highest rating in intensiveness (major) but was considered to have only limited application (receiving an extensiveness rating of only limited for 2010).

Improving Soil-Plant Analysis (107). New techniques have been developed and are expected to be further developed to increase the efficiency of fertilization. The benefits from the use of these techniques are an increase in crop yield and a decrease in fertilizer runoff. The trend was considered to be moderate (in extensiveness) for 1976, but it was expected to be major by 2010. The beneficial implications of the expected use of these techniques received an intensiveness rating of moderate.

Methods of Nutrient Applying (108). This major trend includes a number of subtrends to increase the efficiency on the economics of application. Most of these trends were considered by the panel to have overall beneficial implications; however, two of them received adverse ratings: fall application and aerial and floater application. The panel felt that fall application increases the potential for runoff and, consequently, assigned it an adverse rating of limited. The extensiveness of this subtrend was rated moderate for 1976 and was expected to increase somewhat by 2010. Application by floaters and aircraft was rated at minor extensiveness for 1976; it would increase to only a limited rating by 2010. In intensiveness, the adverse implications of this subtrend were considered to be minor. The subtrend with the greatest implication (beneficial) major in intensiveness, was designated by the panel as that of improved nutrient application. Its extensiveness was rated at important for 1976 and was expected to remain at that level through 2010. The subtrend having the greatest application was the use of liquid fertilizer. It received a rating in extensiveness of major. Its environmental implication, however, was rated as only minor in intensiveness.

Wind Erosion Control (106). Practices included in this trend are strip cropping, barrier rows, and windbreaks, all of which have beneficial effects by stabilizing the soil and impeding sediment movement. All of the practices were considered to have about the same environmental implication by the panel and received a rating in intensiveness of moderate. Strip cropping and barrier rows were expected to have the same application in 2010, receiving a rating of moderate in extensiveness. Wind breaks were expected to have only limited use in 2010.

Developing Nitrogen-Fixation Sources (110). Considerable research is going forward in this area and, according to the panel, much more needs to be done. Nitrogen-fixation would benefit the environment by a reduction in the application of commercial fertilizers resulting in less nutrient runoff. Fixation in non-legumes offers the greatest potential for reducing fertilizer use; however, much research is required before any significant breakthrough can be expected. Consequently, the panel rated the extensiveness of this subtrend as minor for 1976 and moderate in 2010. Its intensiveness received a moderate rating. Fixation in legume sources was considered to be of limited extensiveness for 1976 and was expected to increase only slightly by 2010. The intensiveness of this subtrend was rated as only limited.

Improving Pesticide Application (113). This trend was rated as tenth in importance by the panel. Subtrends include improved application of pesticides by aircraft and floaters, dual application of fertilizer and pesticides, and pesticide placement improvement. The environmental implications in terms of their intensiveness, of all of these subtrends were considered by the panel to be beneficial. Improving placement was considered to have the most extensive application (limited for 1976 and important by 2010) as well as the highest rating in intensiveness (moderate). The trend rated lowest in extensiveness was the improving of floater application. Considered to have a minor rating for 1976, it would become only limited for 2010. The remaining subtrends received moderate to important ratings in extensiveness; however, in each case, the intensiveness was rated as minor.

Other Trends. Trends ranked 11 to 15 in Exhibit VI-1 received relatively low adjusted rankings from the panel, except for that of Developing Improved Fertilizers (111). This trend received a rating nearly equal to that for the tenth trend (Improving Pesticide Application). Using Increased Rates and Amounts of Inputs (118) was considered to be of only minor importance by the panel. This consideration was based on the assumption that inputs would be optimized and that applications would be adequate. The individual subtrends were both adverse and beneficial and when taken in light of each other, their overall implications were expected to be minor.

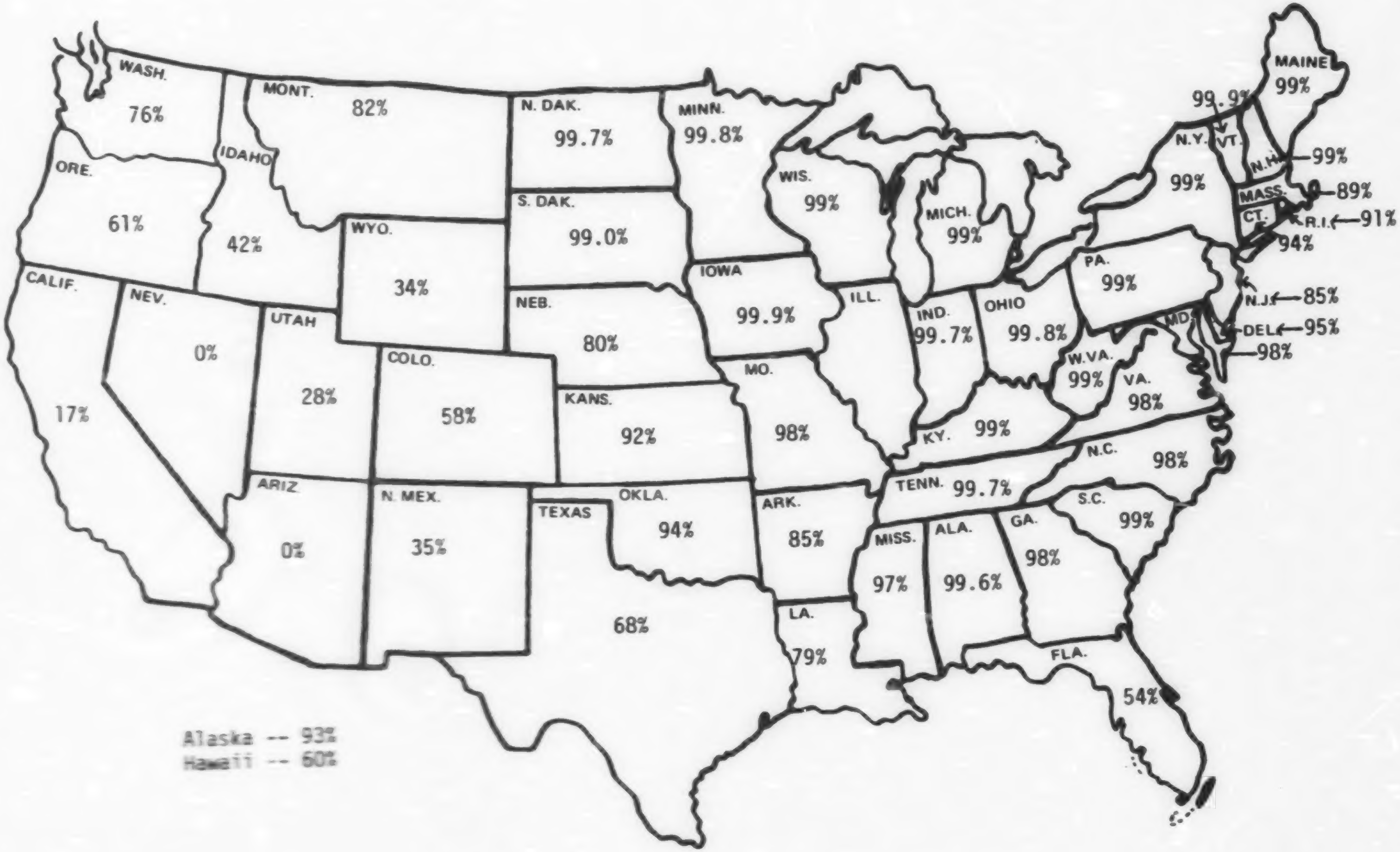
C. Background Summary

The following descriptions and definitions of the trends and management practices related to nonirrigated crop production were provided to the workshop participants as background for the workshop evaluation. In some cases, the workshop panel chose to re-group selected subtrends into new groups or to add/delete subtrends as noted. As such, this summary is quasi-independent of the workshop results as presented in parts A and B, above; but it provides appropriate background base data, definitions and descriptions of the trends and practices assessed in this study.

1. Overview and Base Data

During 1972-74, about 276 million acres of harvested cropland, or close to 90 percent of the total U.S. harvested cropland, were classified as nonirrigated. Exhibit VI-4 shows nonirrigated cropland harvested as a percent of total cropland harvested within each state by the 1969 Census of Agriculture. Essentially all, or 98 percent of the cropland in the thirty Eastern states were classified as nonirrigated. The only significant irrigation of cropland within these states occurred in Florida and Arkansas which irrigated 46 and 15 percent of their cropland respectively.

Exhibit VI-4. Nonirrigated cropland as a percent of total cropland harvested: 1969


WASH.
76%
MONT.
82%
N. DAK.
99.7%
MINN.
99.8%
ORE.
61%
IDAHO
42%
WYO.
34%
S. DAK.
99.0%
WIS.
99%
MICH.
99%
CALIF.
17%
NEV.
0%
UTAH
28%
COLO.
58%
NEB.
80%
IOWA
99.9%
ILL.
IND.
99.7%
OHIO
99.8%
PA.
99%
N.Y.
99%
VT.
99.9%
MAINE
99%
N.H.
99%
MASS.
89%
CT.
94%
R.I.
91%
N.J.
85%
DEL.
95%
MD.
98%
W.VA.
99%
VA.
98%
KANS.
92%
MO.
98%
KY.
99%
N.C.
98%
TENN.
99.7%
S.C.
99%
ARIZ.
0%
N. MEX.
35%
TEXAS
68%
OKLA.
94%
ARK.
85%
LA.
79%
MISS.
97%
ALA.
99.6%
GA.
98%
FLA.
54%

Alaska -- 93%
Hawaii -- 60%

In the seventeen Western states and Louisiana, slightly over 75 percent of the cropland harvested was nonirrigated. Neither Nevada nor Arizona had significant amounts of nonirrigated cropland. Nonirrigated cropland in California amounted to less than 20 percent of the total. Utah, Idaho, Wyoming and New Mexico had less than 50 percent.

The total nonirrigated cropland harvested is projected to increase to 280 million acres in 1985 and to 318 by 2010. The major increases are expected to occur in Minnesota and in the Corn Belt states. Slight decreases are expected to occur in many Eastern seaboard and Northwest states.

Crop production on nonirrigated land contributes, in various degrees, to the pollution of water, air and land. Additionally it may result in other environmental damages to ecology,aesthetics and human health. Its major environmental effects are to surface water and to soil erosion. Although it may cause significant other environmental problems in local areas, such problems are nationally inconsequential.

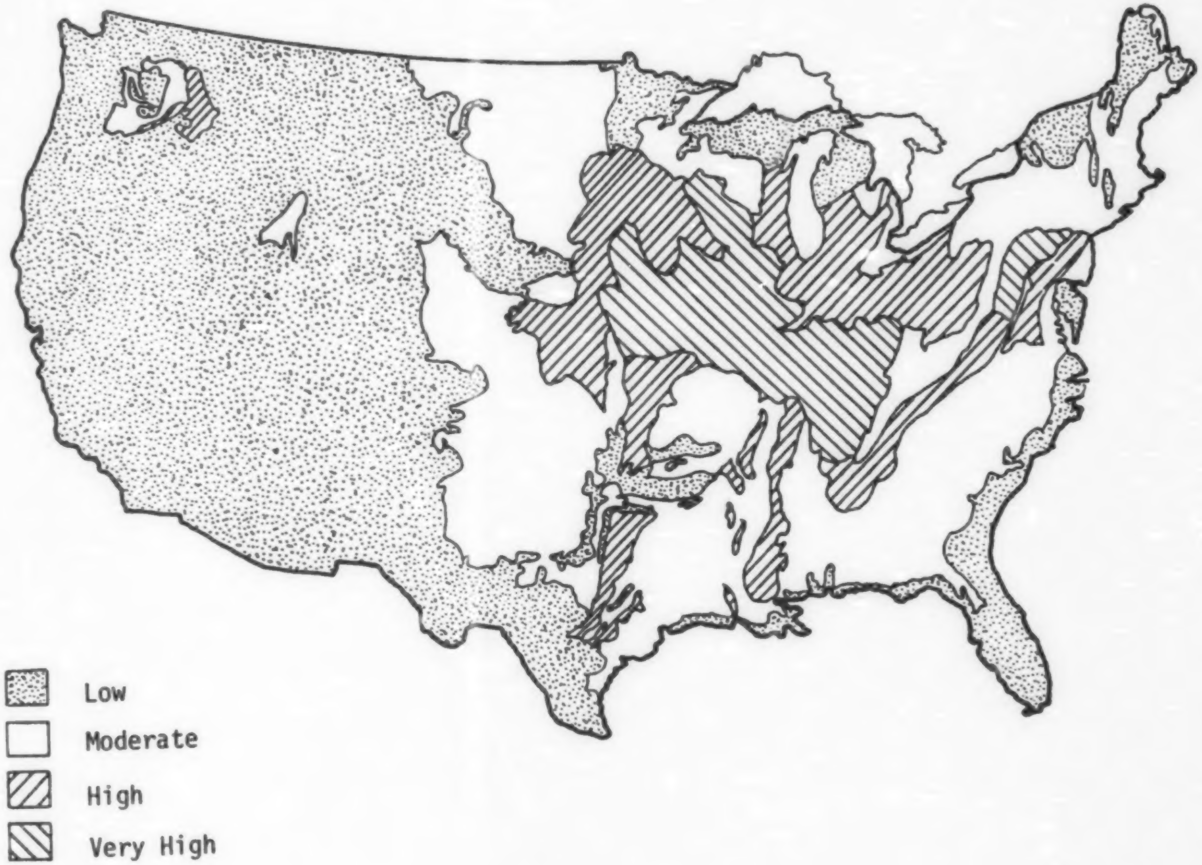
The major nonirrigated cropland pollutants affecting surface water include sediment, pesticides, fertilizer, plus pollutants arising from animal waste, municipal waste and crop residue. They are transported to surface water bodies through direct runoff, sediment movement, and percolation. Sediment movement in addition to transporting pollutants to surface water also constitutes soil erosion, by far the major cause of land pollution.

On the basis of volume, soil erosion sediment is the chief pollutant and it is measured by estimating the average annual rates of soil movement from cropland. Erosion losses from cropland vary from negligible to more than 100 tons per acre. On both irrigated and nonirrigated cropland, an average loss of 8 tons of soil per acre is estimated to occur on 20 percent of the land, between 3 and 8 tons on 50 percent of the land, and fewer than 3 tons on the remaining 30 percent.

Although actual erosion rates have not been mapped on a national scale, the relative potential cropland erosion problems have been estimated as illustrated in Exhibit VI-5. Very high erosion rates are estimated to occur in the Corn Belt and in the western parts of Tennessee and Kentucky. High rates occur in most of the remaining portions of the North Central Region. Low rates generally occur in the Eastern seaboard states, throughout Florida, and along the Gulf Coast.

Estimates made by Holeman (ASCE, 1970) show the annual erosion rates in the contiguous United States at 4 billion tons with about half of this reaching waterways. In recent estimates made by EPA, the annual sediment loading from all cropland was determined to be 1.9 billion tons. Since the major portion of sediment yield comes from nonirrigated harvested cropland, that agricultural land contributes

Exhibit VI-5. Relative potential contribution of cropland to watershed sediment yields.


Low
Moderate
High
Very High

over 50 percent of the nation's total sediment yield to surface waters.

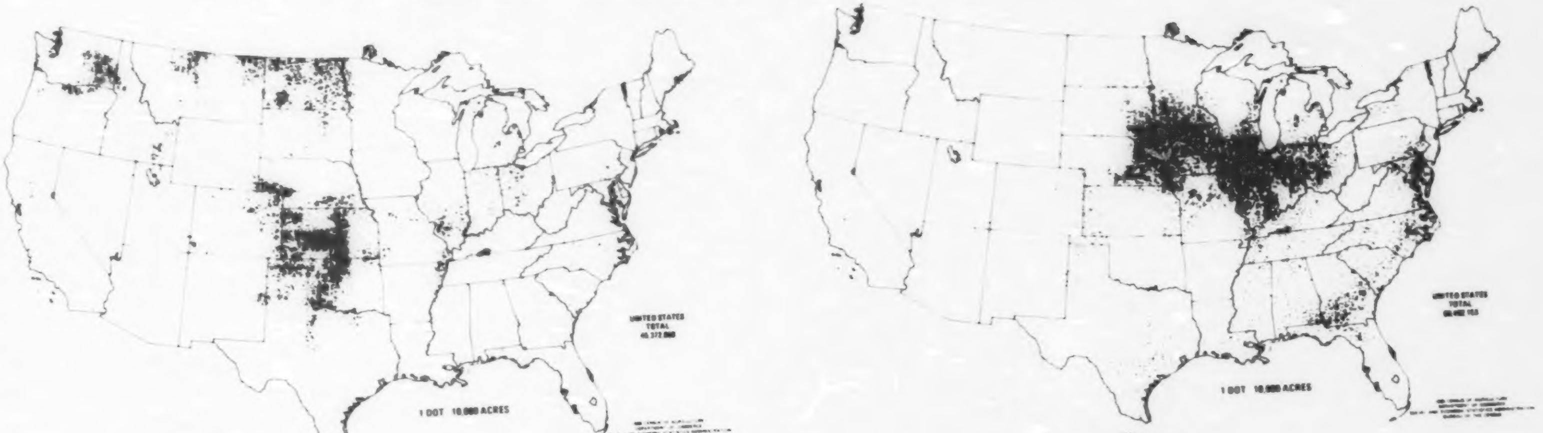
Although sediment is the chief pollutant by volume, fertilizer and pesticides have attracted the greatest public concern. Pollution problems from fertilizers may be expected to occur in those areas in which large numbers of acres receive high rates of application. Exhibit VI-6 shows the location of the major (mostly nonirrigated) cropland harvested for the four most significant crops in terms of total production (corn, soybeans, cotton and wheat). The greatest corn cropland acreage is in the Corn Belt. Most nonirrigated cotton cropland is located along the southern part of the Mississippi River. Nonirrigated soybean cropland is concentrated along the Mississippi River with cotton and in the Corn Belt with corn. Exhibit VI-7 lists the total acres of these crops harvested (1974) and their respective average fertilizer application rates. Corn shows the most acres harvested and the highest application rates. Cotton, the crop with the lowest total acreage harvested, shows the second greatest application rate. The data in the above exhibits indicate those areas having the major potential pollution problems from fertilizers.

Commercial fertilizers contain the plant nutrients nitrogen (N), phosphorus (P) and potassium (K). Since no evidence suggests that K poses any significant problem in water pollution, the only nutrients having environmental implications are N and P. These two nutrients are transported to surface waters largely by two means: nitrogen, relatively soluble, reaches the surface waters via runoff and percolation; phosphorus, relatively insoluble, is attached to sediment and enters the water through sediment movement. Exhibit VI-7 shows the amounts of these nutrients which were applied to the four major crops.

Although commercial fertilizer is the major source of cropland applied nitrogen, supplying over 9 million tons annually, animal wastes (manure) are a significnat source of over 1 million tons. Animal waste can pose more significant local N and P pollution problems than commercial fertilizer when high per acre rates are applied. Since manure is disposed of on cropland in the vicinity of the feedlots in which it was produced, the greater threat of pollution will be concentrated in the major livestock producing areas. Beef feedlots and dairy farms each produce over 300 thousand tons of nitrogen annually. The greatest concentration of beef feedlots disposing of wastes on nonirrigated cropland is found in Nebraska and Iowa. Dairy farms are concentrated rather uniformly throughout the Lake states and the Northeast Farm Production Regions. Hog feedlots produce a total of 300 thousand tons of nitrogen annually and are concentrated in the Corn Belt. Poultry production, yielding 125 thousand tons of nitrogen annually, is concentrated in the Southeast.

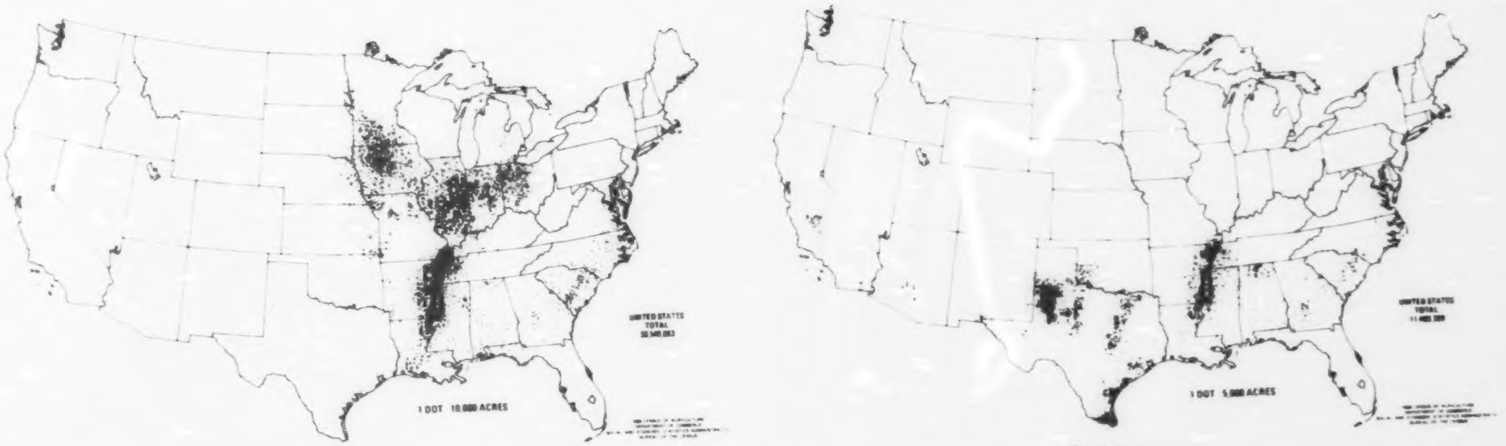
Pesticide pollutants, while minor in terms of total volume, have created great concern because of the toxicity and persistence of some. Little national data exist on pesticide loading from cropland in surface waters. The most recent national survey of agricultural pesticide use was made in 1971, and it showed that a total of 466 million tons was used on

Exhibit VI-6. Location of cropland - corn, soybeans, cotton, wheat.


UNITED STATES TOTAL
1 DOT 10,000 ACRES
UNITED STATES TOTAL
1 DOT 10,000 ACRES

Wheat

Corn


UNITED STATES TOTAL
1 DOT 10,000 ACRES
UNITED STATES TOTAL
1 DOT 5,000 ACRES

Cotton

Soybeans

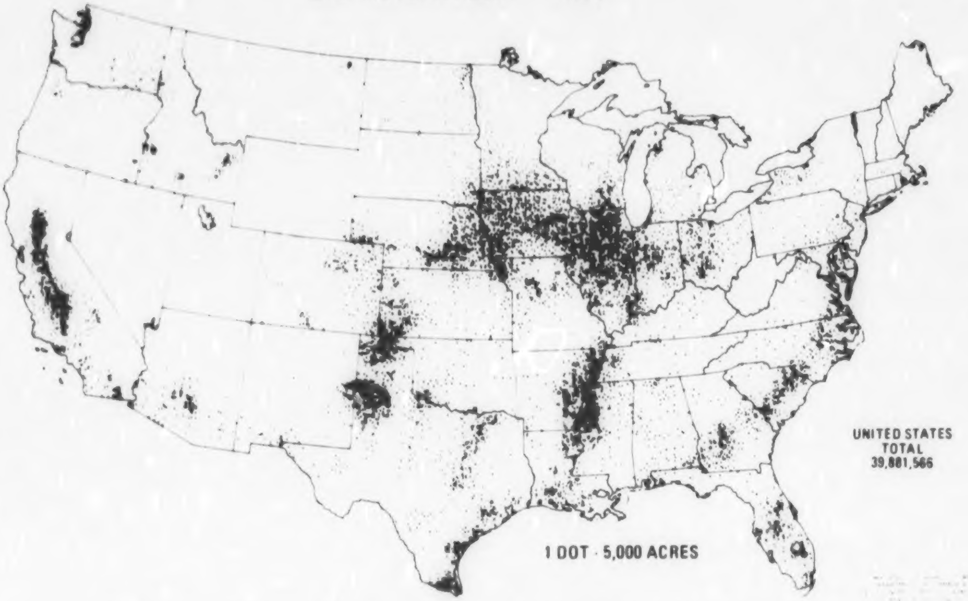
cropland (irrigated and nonirrigated). Sales data estimate that the total increased by close to 70 percent in 1975 with much of the increase attributed to the growing use of conservation tillages which require higher application rates of herbidices. Exhibit VI-8 shows the acreage of crops treated with herbicides and insecticides in 1969, and it is assumed to reflect current usage. Close to 80 percent of all crop pesticides is applied to the four major crops: corn, wheat, cotton, and soybeans; consequently, as illustrated in the exhibit, the major potential pollution of nonirrigated cropland from pesticides is concentrated in those crops' major growing areas. No estimate has been made of the total amount of pesticides entering the nation's streams and rivers; however, many investigations have been made of runoff in local areas. These limited studies suggest that pesticide runoff from cropland is less than 5 percent of the applied amounts. (Caution: Concentration of pesticides, not percent of run-off, produces environmental effects of concern.)

Exhibit VI-7. Acres receiving fertilizer and average fertilizer rates of four crops in the United States, 1974

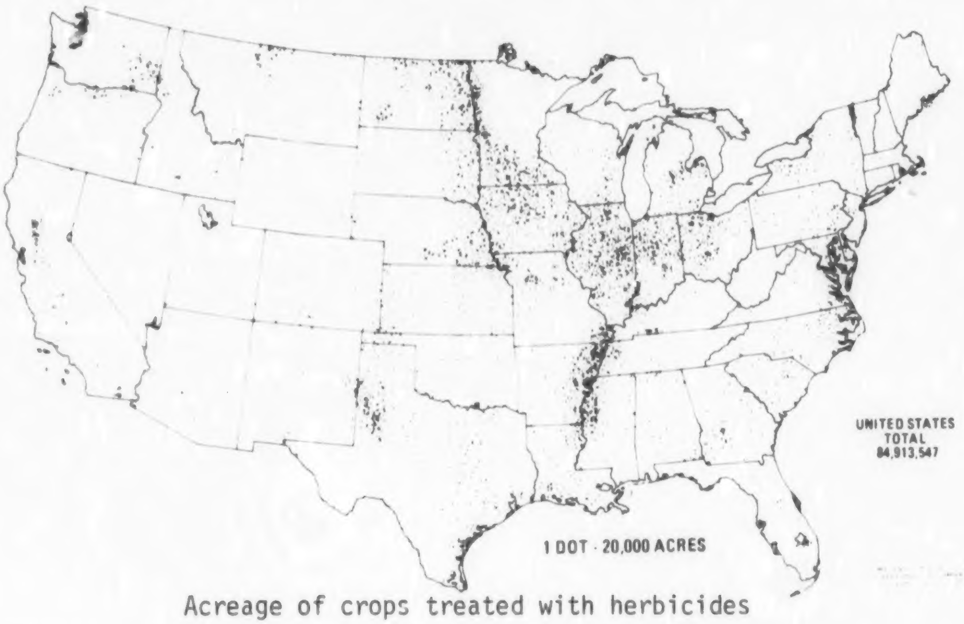
Crop	Acres harvested	Percent fertilized		Pounds/acre rate	
		N	P	N	P
Corn	63.7	94	87	103	27
Cotton	13.1	79	58	78	23
Soybeans	52.5	22	28	15	18
Wheat	64.1	66	46	46	17

Source: U. S. Department of Agriculture/U.S. Environmental Protection Agency, Control of Water Pollution from Cropland, Report No. ARS-H-5-1, Wash. D. C., 1975.

Exhibit VI-8. Croplands treated with pesticides and herbicides: 1969


UNITED STATES
TOTAL
39,881,566
1 DOT · 5,000 ACRES

Acreage of non-hay crops treated with insecticides


UNITED STATES
TOTAL
84,913,547
1 DOT · 20,000 ACRES

Acreage of crops treated with herbicides

Source: Control of Water Pollution from Cropland. Volume I. USDA, EPA. 1975.

2. Trends and Environmental Implications [1]

Crop production on nonirrigated cropland encompasses a wide variety of management practices which differ considerably among crops and among geographical regions. Although the entire production system must be viewed to assess the total impact of this cropland on the environment, each of the practices can be examined to determine its specific environmental implications.

Trends. The general relationships of these management practices within the production system are illustrated in Exhibit VI-9. Included in the system are the management practices (resource management), resource inputs, technological developments, and the production outputs (including residuals generated). This system provided the framework in which the trends in crop production on nonirrigated cropland were identified. Those trends discussed and analyzed are listed in Exhibit VI-10 and subsequently described in Exhibit VI-11. The specific trends have been grouped under the following major practices: (1) crop management, (2) soil-water management, (3) nutrient management, and (4) pest control. The trends, expressed in brief terms, implicitly reflect the adoption or the increasing utilization of the specific management practice.

Environmental Implications. In the Contractor's preliminary analysis of the trends, a matrix (Exhibit VI-12) was developed so that the potential interactions between the specific practices and the generation of pollutants could be examined. These interactions represent changes that would occur in the amount of pollutants produced on a representative unit of production (acre of nonirrigated cropland) if it were cropped under conventional practice and conditions prevalent in 1976. The interactions were denoted by pluses (+) and minuses (-) (+ represents a decreasing effect or beneficial environmental impact; - denotes an adverse environmental impact). The matrix not only illustrates the interactions between specific practices and pollutants generated, but also represents, in certain cases, logical interactions among practices. For example, the primary impact of no-till planting is a decrease in soil sediment; however, no-till requires an attendant increase in the use of pesticides. Consequently, this increase is reflected in the matrix as an interaction between the practice of no-till and the generation of pesticide pollutants. Based on a review of the interactions displayed in the matrix, general conclusions were drawn about the trends and environmental implications.

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[1] Though not of substantive concern affecting the trend rankings and practice assessments arrived at in this study, major trend categories discussed in these base data were in some cases regrouped by the workshop panels to facilitate assessments. These changes are as follows for Panel 1:

Base data category	became	Revised category
103, 114		119
112, 117		120
115, 116		121

Exhibit VI-9. Crop production system: Nonirrigated Cropland

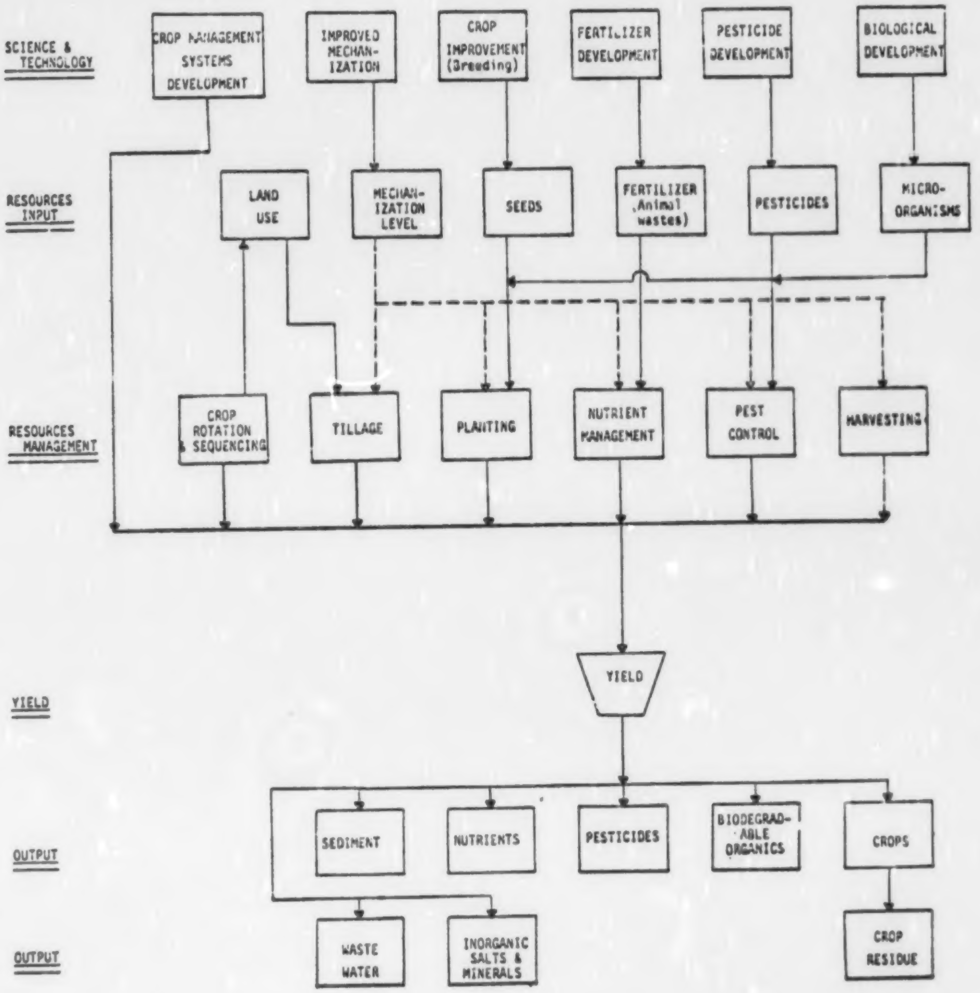
SCIENCE & TECHNOLOGY
CROP MANAGEMENT SYSTEMS DEVELOPMENT
IMPROVED MECHAN-IZATION
CROP IMPROVEMENT (Breeding)
FERTILIZER DEVELOPMENT
PESTICIDE DEVELOPMENT
BIOLOGICAL DEVELOPMENT
RESOURCES INPUT
LAND USE
MECHAN-IZATION LEVEL
SEEDS
FERTILIZER (Animal wastes)
PESTICIDES
MICRO-ORGANISMS
RESOURCES MANAGEMENT
CROP ROTATION & SEQUENCING
TILLAGE
PLANTING
NUTRIENT MANAGEMENT
PEST CONTROL
HARVESTING
YIELD
YIELD
OUTPUT
SEDIMENT
NUTRIENTS
PESTICIDES
BIODEGRAD-ABLE ORGANICS
CROPS
OUTPUT
WASTE WATER
INORGANIC SALTS & MINERALS
CROP RESIDUE

Exhibit VI-10. Environmentally-related trends: Nonirrigated Cropland

CROP MANAGEMENT TRENDS

- 101. CONSERVATION TILLING
    - a. No-tillage
    - b. Reduced tillage: chisel plowing, undercutting, chemical
- 102. CROP SEQUENCING
    - a. Mono-crop sequencing
    - b. No-meadow crop sequencing
    - c. Relay cropping
    - d. Double cropping
- 103. SEED/PLANT IMPROVING */ (Genetic development)
    - a. Weather resistance
    - b. Salt tolerance
    - c. Production efficiency

SOIL WATER MANAGEMENT TRENDS

- 104. RUN-OFF AND EROSION CONTROLLING
    - a. Contour farming: contour planting, contour-strip cropping
    - b. Using terraces and grass waterways
    - c. Using winter cover crops
    - d. Optimizing time of operations: tillage, planting
    - e. Using narrow rows
    - f. Using chemical erosion-control agents
- 105. MOISTURE CONSERVING (STORAGE)
    - a. Fallow cropping: moisture storage, salt-seeps
    - b. Using evapo-transpiration reducing agents
- 106. WIND EROSION CONTROLLING
    - a. Using strip cropping (other than contour-strip)
    - b. Using barrier rows (crops)
    - c. Using free windbreaks

Exhibit VI-10 (continued)

NUTRIENT MANAGEMENT TRENDS

107. IMPROVING SOIL-PLANT ANALYSIS (CROP LOGGING)

108. METHODS OF NUTRIENT APPLYING
    a. Using foliar fertilization
    b. Using multiple applications
    c. Using fall application
    d. Using liquid fertilizers
    e. Using aerial and floater application
    f. Using improved nutrient placement

109. USING ALTERNATIVE NUTRIENT SOURCES
    a. Using animal wastes
    b. Using municipal treatment plant wastes
    c. Using green manure crops

110. DEVELOPING BIOLOGICAL NITROGEN-FIXATION SOURCES
    a. Developing legume sources
    b. Developing non-legume sources

111. DEVELOPING IMPROVED FERTILIZERS
    a. Developing controlled-release fertilizers
    b. Developing high nitrogen content fertilizers
    c. Developing high phosphate content fertilizers

PEST CONTROL TRENDS

112. USING SCOUTING */
    a. Using surface scouting
    b. Using remote sensing scouting

113. IMPROVING PESTICIDE APPLICATION METHODS AND TIMING
    a. Improving aerial application
    b. Improving floater vehicle application
    c. Developing fertilizer and pesticide dual application
    d. Improving pesticide placement

Exhibit VI-10 (continued)

114. DEVELOPING RESISTANT CROPS */
   a. Developing disease resistant crops
   b. Developing insect and nematode resistant crops
   c. Developing bird resistant crops

115. DEVELOPING NEW PESTICIDES */
   a. Developing micro-encapsulated pesticides
   b. Developing systemic pesticides
   c. Developing surfactants for herbicides
   d. Developing bio-degradable pesticides
   e. Developing alternative formulations

116. DEVELOPING BIOLOGICAL CONTROLS */
   a. Developing juvenile hormones
   b. Developing pheromones
   c. Developing sterile males
   d. Developing predators and parasites

117. DEVELOPING INTEGRATED CONTROLS */
(i.e., chemical-biological-mechanical)

RESOURCE USE TRENDS

118. USING INCREASED RATES AND AMOUNTS OF CROP PRODUCTION INPUTS
   a. Using commercial fertilizers
   b. Using other nutrient sources: livestock wastes, municipal sludges
   c. Using chemical pesticides: herbicides, insecticides, fungicides, rodenticides, etc.
   d. Using energy: petroleum products, electricity, sunlight
   e. Using new cropland (including set-aside lands)

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*/ See subsection C-2: Trends and Environmental Implications, for changes in trend groupings by the evaluation workshop.

Exhibit VI-11. Description of environmentally-related trends and developments: Nonirrigated Cropland

CROP MANAGEMENT TRENDS

101. CONSERVATION TILLING - general reduction in cropland soil disturbance
    a. No till plant: seeding without pre-planting tillage
    b. Reduced tillage: weed control and soil breaking with limited soil inversion coupled with chemical treatment

102. CROP SEQUENCING - cropping patterns
    a. Mono-cropping: successive planting of one crop on the same plot of land
    b. No-meadow: eliminates pastures or meadows from rotation sequence
    c. Relay cropping: planting the second crop before the first crop is harvested
    d. Double cropping: planting the second crop after the first crop is harvested in the same growing season

103. SEED/PLANT IMPROVING */
    a. Weather resistance: plants genetically developed to withstand winds, drought, etc.
    b. Salt tolerance: developing plants capability to produce in a saline environment
    c. Production efficiency: genetic development of plants which utilize nutrients and sunlight more efficiently and have desired growth characteristics of root development, growth and maturity.

SOIL WATER MANAGEMENT TRENDS

104. RUNOFF AND EROSION CONTROLLING
    a. Contour farming: farming operations are performed according to the land evaluations
    b. Terracing: soil embankments which slow the downhill flow of surface waters
    c. Cover crops: stubble mulching and grassed waterways to slow runoff flow.
    d. Optimizing time of operation: performing farm operations to minimize the time period that the soil is bare
    e. Narrow rows: reducing the distance between adjoining rows of seeded crops
    f. Chemical erosion-control: Chemical agents applied to reduce soil erosion

Exhibit VI-11 (continued)

105. MOISTURE CONSERVATION
   a. Fallow - allowing the land to rest during one year of cropping rotation to enhance moisture and nutrient content
   b. Evapo-Transpiration: agents used to reduce moisture loss through leaf surfaces

106. WIND-EROSION CONTROLLING
   a. Strip cropping: dividing the field in alternate narrow bands of crop and fallow land
   b. Barrier rows: use of taller crops to act as wind breaks
   c. Wind breaks: planting trees and shrubs to reduce the effect of the wind and soil loss

NUTRIENT MANAGEMENT TRENDS

107. IMPROVING SOIL-PLANT ANALYSIS (crop logging) - monitoring nutrient uptake, soil nutrients available, and plant condition to provide information to adjust fertilizer rates, timing, and cultural practices

108. METHODS OF NUTRIENT APPLYING
   a. Foliar fertilization: applying fertilizer as a spray so that nutrients are taken up through the leaves of the plant
   b. Multiple application: fertilizer is applied more than one time to realize optimum growth and crop production
   c. Fall fertilization: application of fertilizer during the fall season prior to the crops primary growing season
   d. Liquid fertilizer: application of nutrients as a liquid to enhance crop production
   e. Aerial and floater application: fertilizer is applied via airplane, helicopter, or by ground machines equipped to traverse wet and dry ground with limited soil compactions
   f. Improved nutrient placement: aerial, water, side band broadcast application methods

USING ALTERNATIVE NUTRIENT SOURCES
   a. Animal wastes: solid and liquid wastes from livestock feedlots contain nutrients and organic matter.
   b. Municipal treatment plant wastes: use of municipal wastes as a source of nutrients
   c. Green manure crops: crops grown for the intended purpose of incorporating immature plants into the soil structure

Exhibit VI-11 (continued)

110. DEVELOPING BIOLOGICAL NITROGEN-FIXATION SOURCES
   a. Legumes: plants capable of fixing atmospheric nitrogen and accumulating it in root nodules
   b. Non-legume: soil microbacterial populations that are able to fix nitrogen from the air.

111. DEVELOPING IMPROVED FERTILIZERS
   a. Controlled-release: chemical inhibitors to delay nitrification, leaching etc. are added to fertilizers
   b. High nitrogen content: use ammonia to supply a high concentration of nitrogen
   c. High phosphorus content: use of polyphosphates to increase phosphorus content about 50 percent more than ordinary fertilizers

PEST CONTROL TRENDS

112. USING SCOUTING */
   a. Surface: determine types of pests and potential crop damage by visual inspection
   b. Remote sensing: insect populations and locations are determined by satellite information

113. IMPROVING PESTICIDE APPLICATION METHODS AND TIMING
   a. Aerial application: new methods to decrease pesticide drift during application by increasing and homogeneous partical size
   b. Floater vehicle: can be used on wet soil for timely application
   c. Dual application: herbicides, pesticides, and liquid fertilizer simultaneous application

   d. Pesticide placement: using the most effective and efficient manner for applying pesticides

114. DEVELOPING RESISTANT CROPS */
   a. Disease resistant: genetically developing plant species capable of resisting specific diseases
   b. Insect and nematode resistant: genetically developing plant species capable of resisting selected insects and nematodes
   c. Bird resistant: genetically developing plant species that are less accessible to feeding bird populations

Exhibit VI-11 (continued)

115. DEVELOPING NEW PESTICIDES[*/]
    a. Micro-encapsulated pesticides: pesticides in microcapsule form that slowly release the pesticide over a longer time period
    b. Systemic pesticides: pesticide compounds that are absorbed by the plant which make it toxic to pests
    c. Surfactants: chemical materials which enhance the adsorption and absorbtion properties of herbicides
    d. Bio-degradable pesticides: chemicals which are affective against pests and are decomposable by the environment with limited persistence.
    e. Alternative formulations: different methods combining chemicals which are effective against pests.

116. DEVELOPING BIOLOGICAL CONTROLS [*/]
    a. Juvenile hormones: Hormonal compounds capable of preventing normal development and maturation of insects
    b. Pheromones: chemical compounds containing organophosphorus insecticide used to selectively attract insects.
    c. Sterile males: release sexual sterile insects to decrease or control insect population
    d. Predators and parasites: use of natural enemies, fungi, virsuses, bacteria, to control insect populations

117. DEVELOPING INTEGRATED CONTROLS[*/]-integrating chemical, biological, and mechanical treatment methods to achieve desired control over cropland production

RESOURCE USE TRENDS

118. USING INCREASED RATES AND AMOUNTS OF CROP PRODUCTION INPUTS - increasing demands for cropland production will affect the quantity of fertilizer, animal and municipal wastes, chemicals, energy and land used for food production

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[*/] See subsection C-2: Trends and Environmental Implications, for changes in trend groupings by the evaluation workshop.

Exhibit VI-12. Environmentally-related trends: Nonirrigated Cropland

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
CROP MANAGEMENT TRENDS																
101. CONSERVATION TILLING	+	+	+	-	0	-	-	-	0	0	+	+	0	0	-	-
a. No-tillage	+	+	+	-	0	-	-	-	0	0	+	+	0	0	-	-
b. Reduced tillage: chisel plowing, undercutting, chemical	+	+	+	-	0	-	-	-	0	0	+	+	0	0	-	-
102. CROP SEQUENCING	-	-	-	-	0	0	0	-	0	0	-	-	0	0	-	0
a. Mono-crop sequencing	-	-	-	-	0	0	0	-	0	0	-	-	0	0	-	0
b. No-meadow crop sequencing	-	-	-	-	0	-	+	-	0	0	-	-	0	0	-	-
c. Relay cropping	+	+	+	+	0	-	-	-	0	0	+	+	0	0	-	-
d. Double cropping	+	+	+	+	0	-	-	-	0	0	+	+	0	0	-	0
103. SEED/PLANT IMPROVING (Genetic development)	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	-
a. Weather resistance	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	-
b. Salt tolerance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c. Production efficiency	+	+	+	0	0	-	-	0	0	0	+	+	0	0	0	-
SOIL WATER MANAGEMENT TRENDS																
104. RUN-OFF & EROSION CONTROLLING	+	+	+	+	0	+	-	-	-	0	+	+	0	0	-	-
a. Contour farming: contour planting, contour-strip cropping	+	+	+	+	0	+	-	-	-	0	+	+	0	0	-	-
b. Using terraces & grass waterways	+	+	+	+	0	+	-	-	-	0	+	+	0	0	-	-
c. Using winter cover crops	+	+	+	+	0	+	-	-	-	-	+	+	0	0	-	-
d. Optimizing time of operation: tillage, planting	+	+	+	+	0	0	+	+	+	0	+	+	0	0	+	0
e. Using narrow rows	+	+	+	+	0	-	+	+	0	-	+	+	0	0	+	-
f. Using chemical erosion-control agents	+	+	+	+	0	0	-	-	-	0	+	+	0	0	-	0
105. MOISTURE CONSERVING (STORAGE)	-	0	-	+	-	+	-	+	-	+	-	-	-	0	0	-
a. Fallow cropping: moisture storage, salt-seeps	-	0	-	+	-	+	-	+	0	+	-	-	-	0	0	-
b. Using evapo-transpiration reducing agents	+	0	+	0	0	0	-	0	-	0	+	+	+	0	0	0

Exhibit VI-12 (continued)

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
106. WIND EROSION CONTROLLING	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	0
a. Using strip cropping (other than contour-strip)	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	0
b. Using barrier rows (crops)	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	0
c. Using free windbreaks	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	0
NUTRIENT MANAGEMENT TRENDS																
107. IMPROVING SOIL-PLANT ANALYSIS (CROP LOGGING)	0	+	+	0	0	0	+	0	0	0	0	0	0	0	0	0
108. METHODS OF NUTRIENT APPLYING	+	-	0	0	0	0	+	0	0	0	0	+	0	0	0	0
a. Using foliar fertilization	+	0	0	0	0	0	+	0	0	0	0	+	0	0	0	0
b. Using multiple applications	-	-	-	0	0	0	+	0	0	0	0	-	0	0	0	0
c. Using fall application	-	0	0	0	0	0	-	0	0	0	0	-	0	0	0	0
d. Using liquid fertilizers	+	0	0	0	0	0	-	0	0	0	0	+	0	0	0	0
e. Using aerial and floater application	+	0	0	0	0	0	+	0	0	0	0	+	0	0	0	0
f. Using improved nutrient	+	+	+	0	0	0	+	0	0	0	0	+	0	0	0	0
109. USING ALTERNATIVE NUTRIENT SOURCES	+	-	-	0	0	-	-	0	0	-	-	+	0	0	0	0
a. Using animal wastes	+	-	-	0	0	-	-	0	0	-	-	+	0	0	0	0
b. Using municipal treatment plant wastes	+	-	-	0	0	-	-	0	0	-	-	+	0	-	0	0
c. Using green manure crops	-	+	+	0	0	-	-	0	0	+	-	-	0	0	0	0
110. DEVELOPING BIOLOGICAL NITROGEN-FIXATION SOURCES	+	+	0	0	0	-	+	0	0	0	+	+	0	0	0	-
a. Developing legume sources	+	+	0	0	0	-	+	0	0	0	+	+	0	0	0	-
b. Developing non-legume sources	+	+	0	0	0	-	+	0	0	0	+	+	0	0	0	-
111. DEVELOPING IMPROVED FERTILIZERS	0	+	+	0	0	0	+	0	0	0	0	0	0	0	0	0
a. Developing controlled-release fertilizers	0	+	+	0	0	0	+	0	0	0	0	0	0	0	0	0
b. Developing high nitrogen content fertilizers	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0
c. Developing high phosphate content fertilizers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit VI-12 (continued)

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
PEST CONTROL TRENDS																
112. USING SCOUTING	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
a. Using surface scouting	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
b. Using remote sensing scouting	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
113. IMPROVING PESTICIDE APPLICATION METHODS AND TIMING	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
a. Improving aerial application	0	0	0	+	0	0	0	0	0	0	0	0	0	0	+	0
b. Improving floater vehicle application	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
c. Developing fertilizer and pesticide dual application	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
d. Improving pesticide placement	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
114. DEVELOPING RESISTANT CROPS	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
a. Developing disease resistant crops	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
b. Developing insect and nematode resistant crops	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
c. Developing bird resistant crops	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
115. DEVELOPING NEW PESTICIDES	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
a. Developing micro-encapsulated pesticides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
b. Developing systemic pesticides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
c. Developing surfactants for herbicides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
d. Developing bio-degradable pesticides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
e. Developing alternative formulations	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0

Exhibit VI-12 (continued)

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
116. DEVELOPING BIOLOGICAL CONTROLS	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
a. Developing juvenile hormones	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	-
b. Developing pheromones	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
c. Developing sterile males	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
d. Developing predators and parasites	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
117. DEVELOPING INTEGRATED CONTROLS (i.e., chemical-biological-mechanical)	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
RESOURCE USE TRENDS																
118. USING INCREASED RATES AND AMOUNTS OF CROP PRODUCTION INPUTS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
a. Using commercial fertilizers	-	-	-	0	0	-	-	0	0	-	-	-	0	0	0	-
b. Using other nutrient sources: livestock wastes, municipal sludges	-	-	-	0	0	-	-	0	0	-	-	-	0	0	0	-
c. Using chemical pesticides: herbicides, insecticides, fungicides, rodenticides	-	0	0	-	0	0	0	-	0	0	-	-	0	0	-	0
d. Using energy: petroleum products, electricity, sunlight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
e. Using new cropland (including set-aside lands)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(a) Crop management trends. The principal trends projected in crop management involve conservation tilling, crop sequencing, and seed/plant improving. In conservation tilling (101), the increased utilization of no-tillage and reduced tillage practice will have the following major impacts on both water and soil quality: (1) the reduction in soil disturbance and the greater cover of residue on the cropland will impede soil erosion by reducing runoff, and this, in turn, will reduce the sedimentation of the surface water. (2) Although direct runoff can be expected to decrease, percolation and leaching will increase since a greater part of the moisture will be retained on the cropland. (3) With the increased utilization of conservation tilling, a greater infestation of cropland by insects and diseases will occur; consequently, increased applications of pesticides will be required and will result in a greater potential for pesticides runoff. (4) Conservation tilling may also result in increased nutrient runoff, however, both because of the large amounts of organic matter in the cropland and the prospectively greater applications of fertilizers. (5) Although total runoff will be decreased, nitrogen concentration in that runoff may be increased. (6) The increased percolation, will increase the potential for nitrates entering ground water. (7) Because of the reduction in sedimentation, movement of phosphorus to surface water will be substantially decreased. Thus, the overall implicatior of conservation tillage will be the reduction of the potential for water and land pollution.

The trends in crop sequencing (102) carry diverse implications. The mono-cropping and no-meadow rotation practices would tend to increase water and land pollution. Under mono-cropping, which increases the threat of insect and disease infestion, pesticide applications may increase. Too, mono-cropping, depending upon the type of crop involved, may increase or decrease erosion. (With row crops, the potential is somewhat increased, those crops affording better cover would decrease the overall potential.) Omitting meadows from the rotation sequence would increase erosion potential and typically require increased fertilizer application. Both of these would contribute to water and land pollution.

Although the above crop sequencing practices would affect the environment adversely, relay - and double-cropping may have indirect beneficial effects. Both of these practices may impede erosion and reduce, in many cases, fertilizer requirements on a unit of output basis, i.e., more intensive double cropping on one location may be preferred to extensive cropping on multiple locations. Slight increases in insecticide requirements would increase the potential for pesticide runoff, however.

Seed/plant improvements (103) environmental effects are largely indirect. These genetic developments primarily affect crop yields and such increases have minor impacts on any given acre of cropland. The most significant implication stemming from increased yields would be a decrease in the cropland required to meet a specific level of demand, and although the overall cropland requirements will continue to increase, that increase would not be as great as it would have been without the improved crops.

(b) Soil-water management trends. Trends in soil-water management include practices designed to reduce runoff and soil erosion, to enhance the moisture storage capacity of the cropland, and to decrease wind erosion. Erosion controls (104) such as contour farming, terracing, and the use of winter cover crops are traditional methods of stabilizing the soil. Their use continues to increase since they are recognized to be environmentally sound and benefit the producers. The principle feature of these practices it that they impede runoff and retard sediment movement and their environmental effect is to reduce both water and land pollution. A secondary effect is that they increase the moisture retained in the soil and percolated. This increased percolation presents a greater potential for nitrates entering the ground water.

Two trends are significant to moisture conservation (105) and storage in the soil: fallow cropping and using agents to reduce evapotranspiration. Fallowing is common in semi-arid areas with rainfall that is insufficient to produce a satisfactory annual crop. It not only promotes nitrification, but it aids in controlling noxious weeds. Additional benefits of fallowing are an increase of soil moisture and a slight decrease in the requirements for nitrogen fertilizer and herbicides. An adverse effect is the increased potential for both wind and soil erosion, particularly when fallowing is accomplished with cultivation. The using of agents to reduce evapotranspiration and, consequently, increase soil moisture could significantly increase crop yields within moisture deficient areas. The effect on the environment is similar to that of increasing crop yields through improved crops (discussed above). The impact is indirect, for the pressure on the increasing requirements for cropland is slightly reduced because of the greater production levels resulting from decreased evapo-transpiration.

Wind erosion (106) damages have been severe during such times as the drought in the 1930's and, more recently, in the 1950's. Although wind erosion is most severe in semi-arid and arid regions under irrigation, it is significant on nonirrigated cropland. Strip-cropping, barrier rows, and tree windbreaks play an important role in offsetting the damages of wind erosion. Reducing wind erosion not only stabilizes the soil and reduces land pollution, but it also impedes sediment movement in active surface waters. These effects, also reduce the potential for air and water (surface) pollution.

(c) Nutrient management trends. In nutrient management, trends with environmental implications include new methods in applying fertilizer, alternative nutrient sources, biological nitrogen-fixation, and certain technological developments. New soil plant analysis techniques (107) for analyzing nutrient requirements of the soil and plants are being developed and utilized. Widespread application of such analyses are expected in the future with benefits not only to crop yield but also to the environment. The significant effect of these analyses is a potential reduction in unnecessary applications of fertilizers and an associated reduction in nutrient runoff.

Methods of nutrient application (108) of commercial fertilizer are receiving increasing utilization. These methods are generally more efficient and cause less soil disturbance during application. Multiple applications are designed to apply the fertilizers on the cropland during times which are most beneficial for nutrient uptake by the plants; this reduces the rate of application during any one period and, consequently, lessens the potential for nutrient runoff. However, multiple applications increase, to a small degree, soil disturbance with a resultant increase in soil erosion potential.

Fall application of fertilizer is increasing significantly. This practice has both beneficial and detrimental effects. The major benefit is that it precludes the application of fertilizer in the spring time when the ground is most vulnerable to erosion forces. On the other hand, the fertilizer remains in the soil a longer period of time before plant uptake and is subject to greater runoff, e.g., snowmelt, and leaching. Also, through percolation, the potential for contaminating surface waters is slightly greate although there is no evidence to show that this has become a problem.

With the increasing sizes of farms, use of floaters in crop management has been increasing dramatically. The high flotation lines reduce compaction and soil disturbance and facilitate a more efficient application of fertilizers on the cropland. This reduces both problems in sedimentation and nutrient runoff. Although application of fertilizer by aircraft is relatively minor at the present, the development of high concentration and foliar types of fertilizer are expected to make this type of application more feasible. This delivery system would facilitate fertilization of cropland at the time nutrient intake was the greatest in the crops and would lessen the amounts of fertilizer subject to runoff. Additionally, there would be little disturbance of the soil with a minimum risk of soil erosion.

Alternative nutrient sources (109) are expected to become more important in crop production. This will result primarily from disposal requirements for feedlot and municipal wastes. Cropland is often a feasible type of land on which these wastes can be disposed. Disposal is normally accomplished by spreading without incorporation; consequently nutrients contained in these wastes are often more vulnerable to runoff than those in commerical fertilizer. In addition, problems with other fertilizers may occur (an inherent difficulty is determining nutrient content of the wastes and nutrient release to the soil). Another problem may exist with heavy metals in municipal waste when applied on cropland.

Biological nitrogen-fixation (110) developments are expected to have far reaching effects on crop production in the future. Expected developments include ways of using nitrogen more efficiently, means of increasing the nitrogen fixing by plant micro-organism, and methods of improving symbiotic relationships between plants and micro-organisms. Also, genetic developments are anticipated in introducing nitrogen-fixing capabilities into non-legume plants requiring high applications of fertilizers such as corn. With such nitrogen fixation developments considerable reductions in fertilizer use would occur. This would reduce potential nitrogen runoff and leaching.

Improved fertilizers (111) developments are expected to occur in the future which will have major effects on practices in nutrient management. Controlled-release fertilizers will decrease the runoff potential of nitrogen into surface water and will decrease the eutrophication in those waters that do receive nutrient loading from fertilizers applied to cropland. Additionally, this development will increase the efficiency of nutrient intake of crops which will reduce the amounts of nutrients available for runoff and leaching. Development of nitrification and leaching inhibitors will reduce problems associated with contamination of ground water. These collective trends in nutrient management (other than the increasing use of fertilizers) are expected to have an overall beneficial effect on the environment.

(d) Pest control trends.[*] Trends in pest control include improved methods of application, scouting, developments in new pesticides, resistant crops and biological controls. Scouting (112) both surface and by remote sensing, is expected to reduce overall pesticide use by reducing the requirements for continued application in areas in which there is no threat of pest infestation.

Improvements in application practices (113) are expected to have beneficial effects. Improvements in aerial application techniques will reduce the amount of pesticides applied to non-target areas with a consequent reduction in pesticide use and a greater efficiency of application. These improvements will result in an increasing share of all pesticides being applied by aircraft. Also, the increasing use of floaters not only promotes efficiency in the application of pesticides, but also facilitates more timely applications. The combined effects of these improvements will be a reduction in pesticide requirements. In addition to the reductions in potential pesticide pollution, a slight reduction in soil erosion will be associated with the floater application.

Developments in dual application of fertilizer and pesticides will carry both favorable and unfavorable implications. Dual application decreases the movement of vehicles across the cropland which would lessen somewhat the disturbance of the soil. However, applications under this technique are generally not optimal for both fertilizer and pesticide use. Consequently, one of the two would be subject to runoff for a period of time greater than necessary.

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[*] See subsection C-2: Trends and Environmental Implications, for changes in trend groupings by the evaluation workshop.

More resistant crop (114) developments are expected to reduce the requirements for pesticides. The most beneficial developments are anticipated in the area of new improved crops resistant to pests such as insects, nematodes, birds, plus diseases. Although no dramatic developments are expected soon, gradual improvements are envisioned which will alleviate some of the potential pesticide problems.

New pesticides (115) are being developed which will have environmental implications. They include formulations such as micro-encapsulated and systemic pesticides. The benefits from these will be derived from their greater efficiencies and the associated reduction in the total level of pesticides required. Surfactants for herbicides will facilitate more timely applications and the use of alternative pesticides. Significant impacts are expected with developments of biodegradable pesticides. These will reduce both the contamination of water (surface and ground) and of the soil itself.

Biological control (116) developments are expected which will also influence pest control practices. Potential developments involve the use of juvenile hormones, pheromones, sterile males, predators, and parasites. Both beneficial and adverse effects may occur with these developments. Biological control, in some cases, would decrease the requirements for pesticides on specific crops. This, of course, would reduce potential pollution problems: however, the introduction of these biological controls could have potential damaging effects on the environment if they affected non-targeted plants or beneficial insects.

(e) Resource use trends. The trends discussed above were viewed in light of impacts which were expected to occur from changes in practices as utilized on a single unit of cropland. In many cases the practices involved changes in the use of resources such as land, pesticides, and fertilizer. Collectively these practices may be expected to have significant effects on resource use and hence on the environment, although the trends with an overriding importance are those of the increasing levels of agriculture inputs associated with the increasing demand for food. The inputs that pose significant environmental implications are fertilizers, pesticides, and land. By the year 2010, the use of fertilizers and pesticides is projected to increase well over a 100 percent while land required for nonirrigated cropland is projected to increase by fifteen percent. These increases, which constitute the basic forces on the environment, bring into focus the fundamental problems involving water, air, and land pollution. All of the practices and developments previously identified must be viewed in this perspective.

SECTION VII

ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 2 - IRRIGATED CROP PRODUCTION

The Irrigated Crop Production Panel assessed and ranked the major environmentally related trends in its' own area of expertise. Using as a basis the preliminary report of trends (see Part C: "Background Summary," below) the panel evaluated and ranked irrigated crop production trends as shown in Exhibit VII-1. A brief description of the top ten trends, and comments concerning their environmental implications, are contained in Exhibit VII-2. Furthermore, the panel's extensiveness of use and intensiveness of effects ratings, which were developed as a means for establishing an overall environmental rating, are presented in Exhibit VII-3. These exhibits are discussed further below.

Panel 2 was comprised of four members and was chaired by R. S. Rauschkalb. It represented a broad background in areas such as economics, crop production, water resource contraol, and irrigation engineering.

Name	Representing	Specialty	Location
Charles M. Hohn	New Mex. St. Un.	Irrigation engineer	Las Cruces, NM
G. L. Horner	USDA-ERS	Economics	Davis, CA
Gene Merrill	St. of Calif.	Water Res. Contr.	Sacramento, CA
R. S. Rauschkalb	Un. of Calif.	Crop production	Davis, CA

A. Major Trend Rankings and Practices Assessments

As discussed previously, (Section IV, "Workshop Procedures") the procedure used by the panel in assessing trends involved an analysis of the extensiveness (E) and intensiveness of effect (I) of each of the subtrends. The product of these two ratings gave a significance rating for the subtrend. Based on an examination of the ratings of all of the subtrends, a composite rating was assigned to each major trend. The final step in ranking the trends was an evaluation of all of the trends and a subsequent adjustment of the ratings in order to reflect a proper weighting among the trends.

Although the Contractor's preliminary report was used as a basis of the panel's assessment, the panel was given the opportunity to modify the trend categories contained in the report. In the case of Panel 2, a number of modifications were made and are discussed below. Included in the trends contained in the preliminary report were a number involving pest control. The panel did not feel that it had sufficient competence in pesticides to adequately assess the implications of these trends.

Exhibit VII-1. Ranking of environmentally-related trends, 1976-2010: Irrigated Crop Production

Panel Rank	Trend Number	Trend	Adjusted Rating
1	(208)	Improving water application	22
2	(204)	Runoff & erosion control	18
3	(211)	Methods of nutrient application	15
4	(220)	Developing integrated controls	12
5	(210)	Using soil-plant analysis	9
6	(209)	Directly monitoring irrigation needs	7
7	(206)	Using sprinkler irrigation	6
8	(203)	Seed/plant improvement	5
9	(213)	Developing nitrogen-fixation sources	5
10	(214)	Developing improved fertilizers	4
11	(221)	Using increased rates and amounts of crop production	3
12	(202)	Crop sequencing	3
13	(212)	Using alternative nutrient sources	3
14	(201)	Conservation tilling	2
15	(205)	Wind erosion control	2
16	(207)	Using drip or trickle irrigation	1

Exhibit VII-2. Description of major environmentally-related trends, 1976-2010: Irrigated Crop Production

Panel Rank	Trend Number and Title	Adjusted Rating for 2010	Comments and Modifications
1	(208) Improving Water Application	22	This trend encompasses those practices which tend to optimize water application to crops and includes irrigation developments and scheduling systems. These practices are expected to have beneficial effects by improving both production efficiency and soil quality, (i.e., reduce pollution loading of sediment, salinity, etc)
2	(204) Runoff & Erosion Control	18	Runoff and erosion control include measures such as contour farming, terracing, and using winter crops in order to stabilize the soil to impede soil movement and water runoff. An important subtrend identified by the panel was land grading.
3	(211) Methods of Nutrient Application	15	New techniques and methods of applying fertilizer are being developed and adopted which increase the efficiency of fertilization and have potential environmental implications, by reducing run-off.
4	(220) Developing Integrated Pest Controls	12	Integration of biological, chemical, and mechanical methods not only increase the efficiency of pest control but benefit the environment as a result of the reduction of pesticide use.
5	(210) Use of Soil-Plant Analysis	9	Increasing use of techniques in soil-plant analyses is expected to benefit the environment through more efficient nutrient management.
6	(209) Directly Monitoring Irrigation Needs	7	Systems used to monitor irrigation requirements significantly improve the efficiency of water application and benefit the environment.
7	(206) Using Sprinkler Irrigation	6	Sprinkler irrigation is most effective when used in connection with shallow rooted plants.
8	(203) Seed/Plant Improving	5	Seed/plant improvements while generally favorable to crop yields were expected to adversely affect the environment because of increasing soil salinity.
9	(213) Developing Nitrogen-Fixation Sources	5	Expected developments include ways of using nitrogen more efficiently, means of increasing the nitrogen fixed by plant micro-organisms, and methods of improving the symbiotic relationships between plants and micro-organisms. These developments would result in appreicable reductions in fertilizer requirements, and reduce nutrient loss in runoff.
10	(214) Developing Improved Fertilizers	4	Developments in controlled release and nitrate inhibitors are expected to increase the efficiency of nutrient application and benefit the environment, by reducing nutrient loading.

Exhibit VII-3. Environmental ratings of top ten trends and associated practices: Irrigated Crop Production

Panel Rank	Trend Number	Trend and Subtrend	Extensiveness Trend Rating			Intensiveness Rating
			1976	1985	2010	2010
1	(208)	Improving Water Application				
		a. Furrow basin	1	0	0	+1
		b. Large sprinklers	1	0	0	-1
		c. Recycling & controlling tailwater	2	3	4	+3
		d. Timing and amount with respect to crop and soil condition	3	4	5	+3
		e. Irrigation scheduling	1	2	3	+5
2	(204)	Runoff & Erosion Control				
		a. Contour farming	1	1	1	+1
		b. Terraces & grass waterways	0	0	1	+2
		c. Winter cover crop	1	1	1	+2
		d. Land grading	4	5	5	+5
3	(211)	Methods of Nutrient Application				
		a. Foliar application	1	1	2	+1
		b. Multiple applications	2	3	4	+3
		c. Fall application	1	1	1	-1
		d. Aerial & floater application	2	2	3	-1
		e. Improved nutrient placement	2	3	4	+3
		f. Irrigation application	2	2	3	+1
4	(220)	Developing Integrated Controls	2	3	4	+2
5	(210)	Using Soil-Plant Analysis	1	2	3	+3
6	(209)	Directly Monitoring Irrigation Needs				
		a. Measuring soil moisture content	1	2	3	+3
		b. Remote sensing of plant or soil water stress	0	1	1	+1
		c. Field soil examination	1	1	1	+2
7	(206)	Using Sprinkler Irrigation	1	2	2	+2
8	(203)	Seed/Plant Improving				
		a. Weather resistance	1	1	1	+1
		b. Salt tolerance	2	3	4	-3
		c. Production efficiency	1	1	2	+1
9	(213)	Developing Nitrogen-Fixation Sources				
		a. Legume sources	1	1	2	+1
		b. Non-legume sources	0	0	1	+4
		c. Non-symbiotic non-legume	0	0	1	+4
10	(214)	Developing Improved Fertilizers				
		a. Controlled release fertilizers	1	1	1	+2
		b. High phosphate content fertilizers	2	2	3	0
		c. Liquid	1	2	2	0
		d. Nitrate inhibitors	0	1	2	+1

Consequently, the list of trends ranked by the panel excludes the pest control trends, (specifically Trends 215 through 219) except for Developing Integrated Controls (220). This trend was considered to cover other aspects of pest control relating to crop management which were within this panel's area of expertise. However, the panel did not want the other trend exclusions to imply that pest control trends were not considered important enough to be ranked among the top ten.

B. Environmental Implications of Major Trends and Practices

Each of the major irrigated crop production trends, as determined by Panel 2, are summarized below. Background descriptions and definitions of these trends which served as the basis for the workshop's evaluations, are included in Part C: "Background Summary," for reference as needed.

Improving Water Application (208). This trend represents a modification of the trend included in the preliminary report (see Part C) as "reducing" water application. The panel concluded that "improving water application" was a more appropriate classification since there are considerable areas in which application will be increased. The trend, as viewed by the panel, reflects a general movement towards an optimization of water application. This trend includes practices (subtrends) which are expected to occur in irrigation developments and improvements in scheduling. As reflected in Exhibit VII-3, the use of furrow basins and large sprinklers will be virtually eliminated by 2010 with the introduction of more modern systems. The extensiveness of use of systems involving recycling and controlling tail water was considered to be only limited in 1976 but was expected to increase to an important level by 2010. The intensiveness of the effects of these systems was considered by the panel to be moderate.

Practices specifically involving the proper timing and amount of application were considered to be in moderate use (extensiveness) in 1976 and were expected, by the panel, to be used widespread in 2010 as reflected in the major rating. The intensiveness (environmental effect) was rated as moderate for these practices. The practice expected to have the greatest environmental impact in 2010 involved irrigation scheduling; it was rated to have a major intensiveness of effect. In extensiveness, its use was considered minor in 1976 but was expected to increase to moderate by 2010.

Runoff and Erosion Control (204). This trend includes those measures designed to stabilize the soil such as contour farming, terracing, and land grading. The latter was a practice identified by the panel which was not included in the preliminary report. The effect of the stabilization brought about by these measures enhances water quality by reducing sedimentation and promotes the retention of the soil quality. Contour farming was considered by the panel to be of minor importance in irrigated crop production both in extensiveness of use and intensiveness of effect. According to the panel, very little terracing or use of grass waterways was done in 1976;

even for 2010, only minor use was expected as reflected in the extensiveness rating. The effect in the areas where they will be used was expected to be beneficial but only of limited importance. The extensiveness in the use of winter cover crops was considered minor in 1976 and was not expected to increase in importance by 2010. The intensiveness of the effect of the practice was expected to be beneficial but again of limited importance. Land grading was considered to be used widely in 1976 and was expected to be of major importance (in extensiveness) by 2010. Also, the environmental effects were expected to be of major significance.

Methods of Nutrient Application (211). A number of innovations in applying commercial fertilizers have been adopted and are being developed which affect the efficiency of nutrient management. In many cases, these practices will have environmental implications both favorable and unfavorable. Two practices which the panel felt would have the most beneficial effects were multiple applications and improved nutrient placement. Both of these practices were rated by the panel as having only limited extensiveness of use in 1976 but were expected to have wider application in 2010, receiving a moderate rating. The intensiveness of effect was expected to be moderate by 2010. Foliar application and application in irrigation were expected to have only minor impacts as shown in the intensiveness rating. Extensiveness ratings of these practices ranged from minor to moderate. Two practices were considered to have potentially adverse impacts, although the actual effects were expected to be minor. Fall application was expected to pose greater potential problems in runoff. However, the extensiveness of use was expected to be minor; consequently, the overall problem was not considered to be significant. Aerial and floater applications were expected to have a minor but detrimental effect principally because of the drift problems associated with aircraft. By 2010, application by these two type vehicles was expected to be at a moderate level.

Developing Integrated Controls (220). The trend in the integration of mechanical, biological, and chemical measures was considered by the panel to have a beneficial effect on the environment because of the overall reductions in pesticide requirements. According to the panel, this system found only limited use in 1976 but is expected to find an increasing use in the future as reflected in the important extensiveness rating received for 2010. The intensiveness in effect of this system was rated as of limited importance in 2010.

Use of Soil-Plant Analysis (210). This trend is a modification of the trend described in the preliminary report as the "improving of soil-plant analysis". In the view of the panel, the significant aspect of the trend was the increasing use of these techniques. Any improvement was considered secondary. According to the panel, the use of these techniques was minor in 1976; however, it will increase in the future to moderate level in 2010. The intensiveness of effect was expected to be moderate by 2010.

Directly Monitoring Irrigation (209). A requirement for efficient water application is the direct monitoring of irrigation needs. Systems designed to accomplish this benefit crop yield and generally benefit the environment by conserving water and, in many cases, reducing the salinity of the soil. Monitoring involves practices such as measuring soil moisture content, remote sensing of plant or soil stress, and examining field soil. According to the panel, the practice having the greatest beneficial effect is that of measuring soil moisture content. It received a moderate rating in intensiveness. Although its extensiveness in use was considered minor for 1976, it is expected to increase to moderate by 2010. Remote sensing had very little application during 1976. However, its use was expected to increase somewhat by 2010. Its intensiveness of effect was rated as minor by the panel. Field soil examination using augers was considered by the panel to have minor application in 1976 and was not expected to increase significantly by 2010. The intensiveness of effect on the environment was expected to have only limited importance by 2010.

Using Sprinkler Irrigation (206). This type of irrigation is being used principally for shallow rooted and high value plants. This method is generally more efficient than furrow and promotes water conservation. Based on this conservational aspect, the panel rated its intensiveness in 2010 as beneficial but only of limited importance. The panel rated this practice as having only limited application (extensiveness) in 2010.

Seed/Plant Improving (203). Three types of improvements were considered by the panel as having environmental implications: weather resistance, salt tolerance, and production efficiency. Those improvements involving increased weather resistance and production efficiency were expected by the panel to have beneficial effects although minor as shown in the intensiveness rating. Additionally the extensiveness of these two type improvements was expected to be of minor or limited importance by 2010. Improvements in salt tolerance were expected to have adverse effects on the environment with an increase in soil salinity as a result of an overall increase in water use. The panel rated this intensiveness of effect as moderate. In extensiveness, the panel considered these improvements to be of limited importance in 1976 but expected then to increase to an important level by 2010.

Developing Nitrogen-Fixation Sources (213). The panel considered both legume and non-legume sources in their assessment of expected developments. In addition to these two, which were contained in the preliminary report, it also considered nitrogen-fixation by non-symbiotic non-legume sources. In their assessment, the panel concluded that fixation in legumes was minor in 1976 and was expected to be of only limited importance in 2010. Fixation by non-legume source (including non-symbiotic) is expected to occur only through long term research. According to the panel, these types were expected to find only a minor level of application by 2010. In intensiveness, nitrogen-fixation by legume sources was expected to have only a limited effect while that of non-legumes was expected to have a major effect.

Developing Improved Fertilizers (214). The panel examined a number of potential developments involving fertilizers and concluded that there would probably be no great environmental impact from these trends. The only developments which were considered to have an effect were those related to controlled fertilizers (limited in intensiveness) and nitrate inhibitors (minor in intensiveness). The panel emphasized that the importance of controlled fertilizers would not be those associated with slow-release.

Other Trends. Other trends assessed included using Increased Rates and Amounts of Crop Production Inputs (221), Crop Sequencing (202), Using Alternative Nutrient Sources (212), Conservation Tilling (201), Wind Erosion Control (205), and Using Drip or Trickle Irrigation (207). The panel concluded that the impacts from these trends would be relatively minor.

C. Background Summary

The following descriptions and definitions of trends and management practices (subtrends) related to irrigated crop production were provided to the workshop participants as background for the workshop evaluation. In some cases, the panel members chose to re-group selected subtrends or add/delete subtrends as noted. As such, this summary is quasi-independent of the workshop results as presented in Parts A and B, above. However, it provides appropriate background base data; definitions and descriptions of the trends and practices assessed in this portion of the overall study.

1. Overview and Base Data

During 1972-74, an estimated 35 million acres of harvested cropland or about 10 percent of the nation's total, were classified as irrigated. [1/] Exhibit VII-4 shows the irrigated cropland as a percent of the total U.S. cropland harvested in 1969. Essentially all of the irrigated cropland was located in the seventeen Western States and Louisiana. Arkansas and Florida. About 3 million acres or 2.3 percent of the cropland in the thirty Eastern States was irrigated, and most was located in Louisiana, Arkansas, and Florida. In the seventeen Western States, there was a total of about 29 million acres of irrigated cropland or 23 percent of the total cropland. About 40 percent of the total irrigated cropland was located in two states: California with 6.9 million acres and Texas with 6.8 million. Only two Western States had no significant amounts of irrigation of cropland--North and South Dakota, each with less than 200 thousand acres each. Exhibit VII-5 shows the total irrigated cropland in specified crops and

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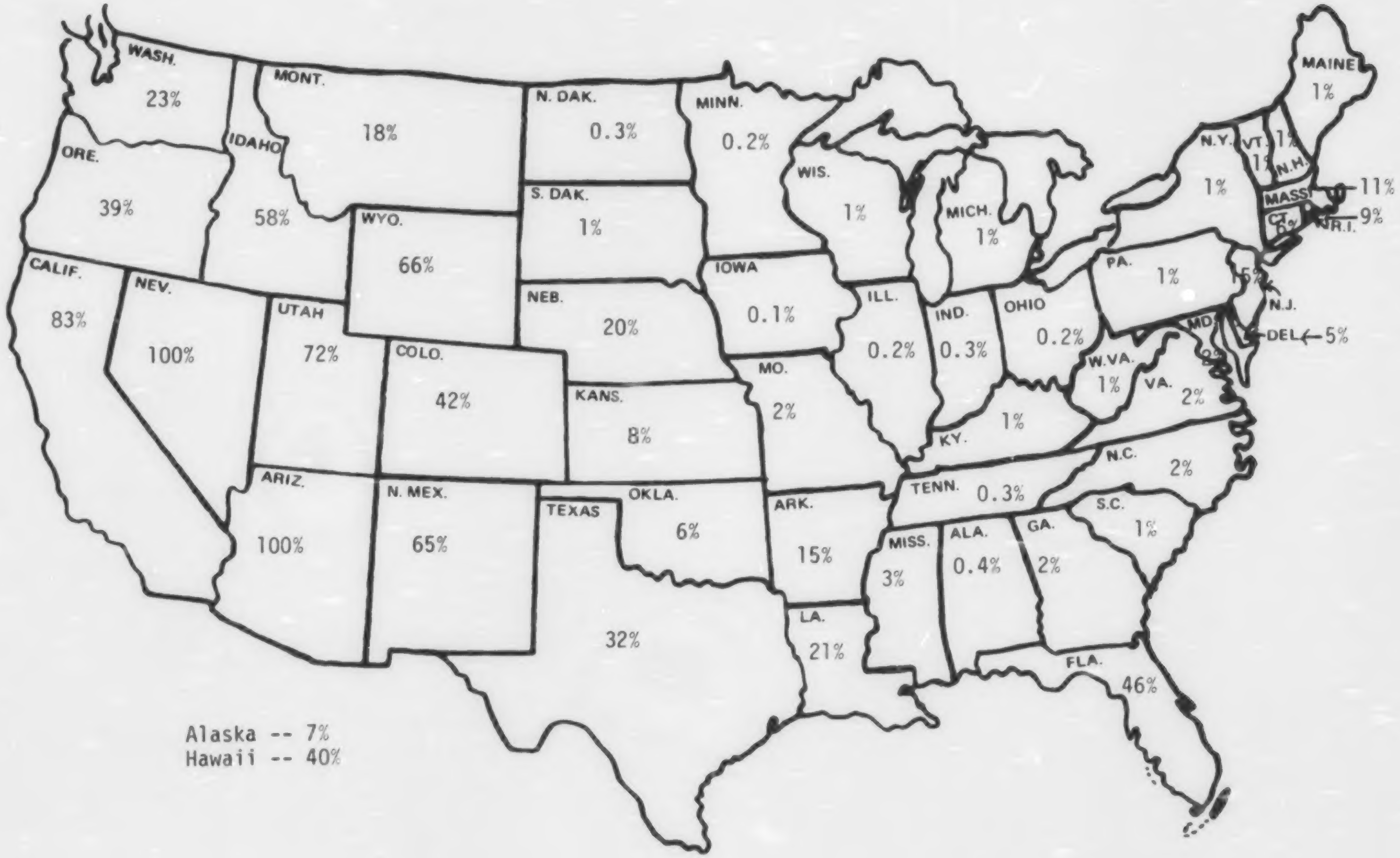
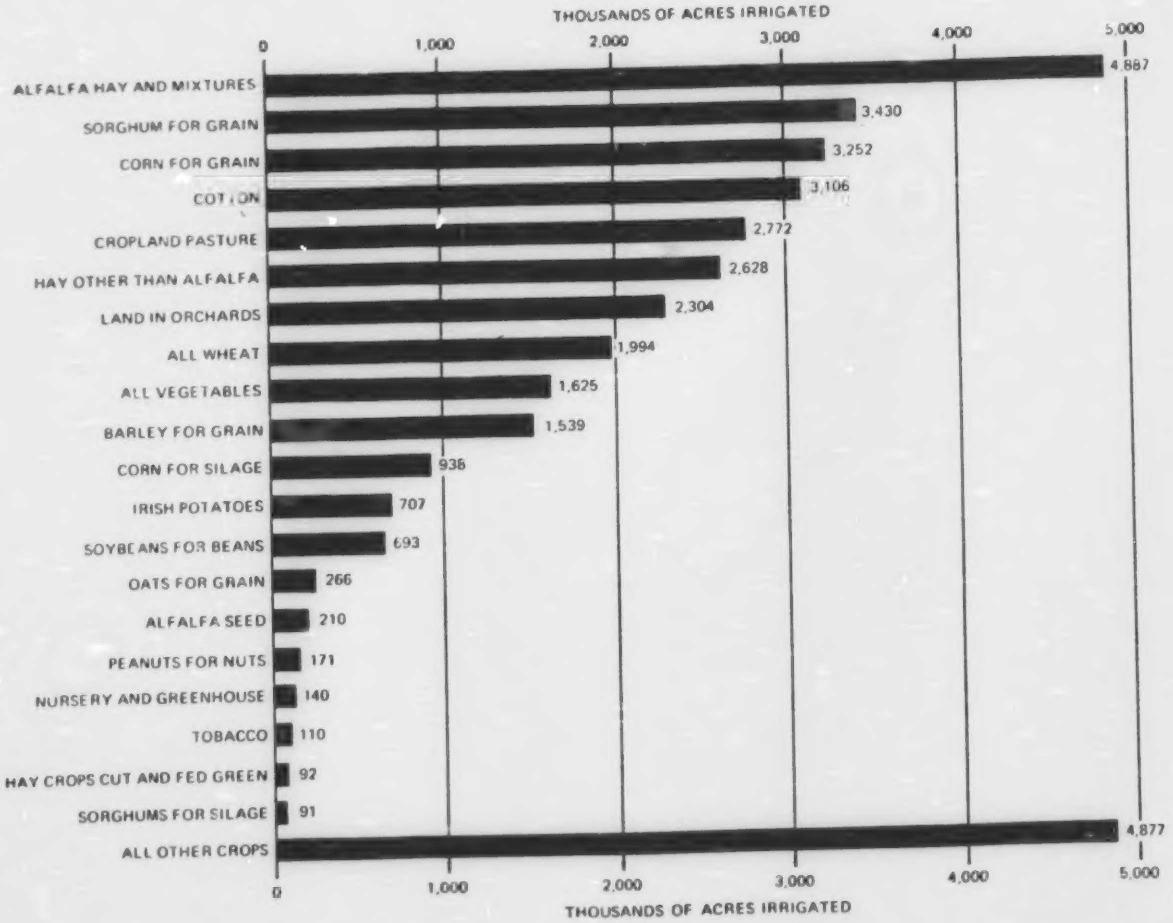
[1/] In 1974, a total of 40.4 million acres was classified as irrigated land, but only an estimated 35 million acres were harvested cropland.

Exhibit VII-4. Irrigated cropland harvested as a percent of total cropland harvested: 1969


WASH. 23%
ORE. 39%
CALIF. 83%
IDAHO 58%
NEV. 100%
MONT. 18%
WYO. 66%
UTAH 72%
ARIZ. 100%
COLO. 42%
N. MEX. 65%
N. DAK. 0.3%
S. DAK. 1%
NEB. 20%
KANS. 8%
OKLA. 6%
TEXAS 32%
MINN. 0.2%
IOWA 0.1%
MO. 2%
ARK. 15%
LA. 21%
WIS. 1%
ILL. 0.2%
MICH. 1%
IND. 0.3%
OHIO 0.2%
KY. 1%
TENN. 0.3%
MISS. 3%
ALA. 0.4%
GA. 2%
FLA. 46%
S.C. 1%
N.C. 2%
VA. 2%
W.VA. 1%
MD. 2%
DEL 5%
N.J. 15%
PA. 1%
N.Y. 1%
VT. 1%
N.H. 1%
MAINE 1%
MASS 11%
CT. 6%
R.I. 9%

Alaska -- 7%
Hawaii -- 40%

Exhibit VII-5. Irrigated cropland in specified crops and pasture on farms: 1969



Source: Department of U.S. Commerce, 1969 Census of Agriculture.

pastures in 1969. Hay (alfalfa and other types) accounted for about 7.5 million acres. Sorghum, corn, and cotton each accounted for over 3 million acres. Wheat was irrigated on less than 2 million acres, and soybeans on about 0.7 million acres.

The total irrigated cropland harvested has continued to rise and is projected to increase to 37 million acres by 1985 and to remain at that level through the year 2010. The greatest increase is expected to occur in Texas, and other significant increases are projected for California, Florida, Nebraska, and Kansas.

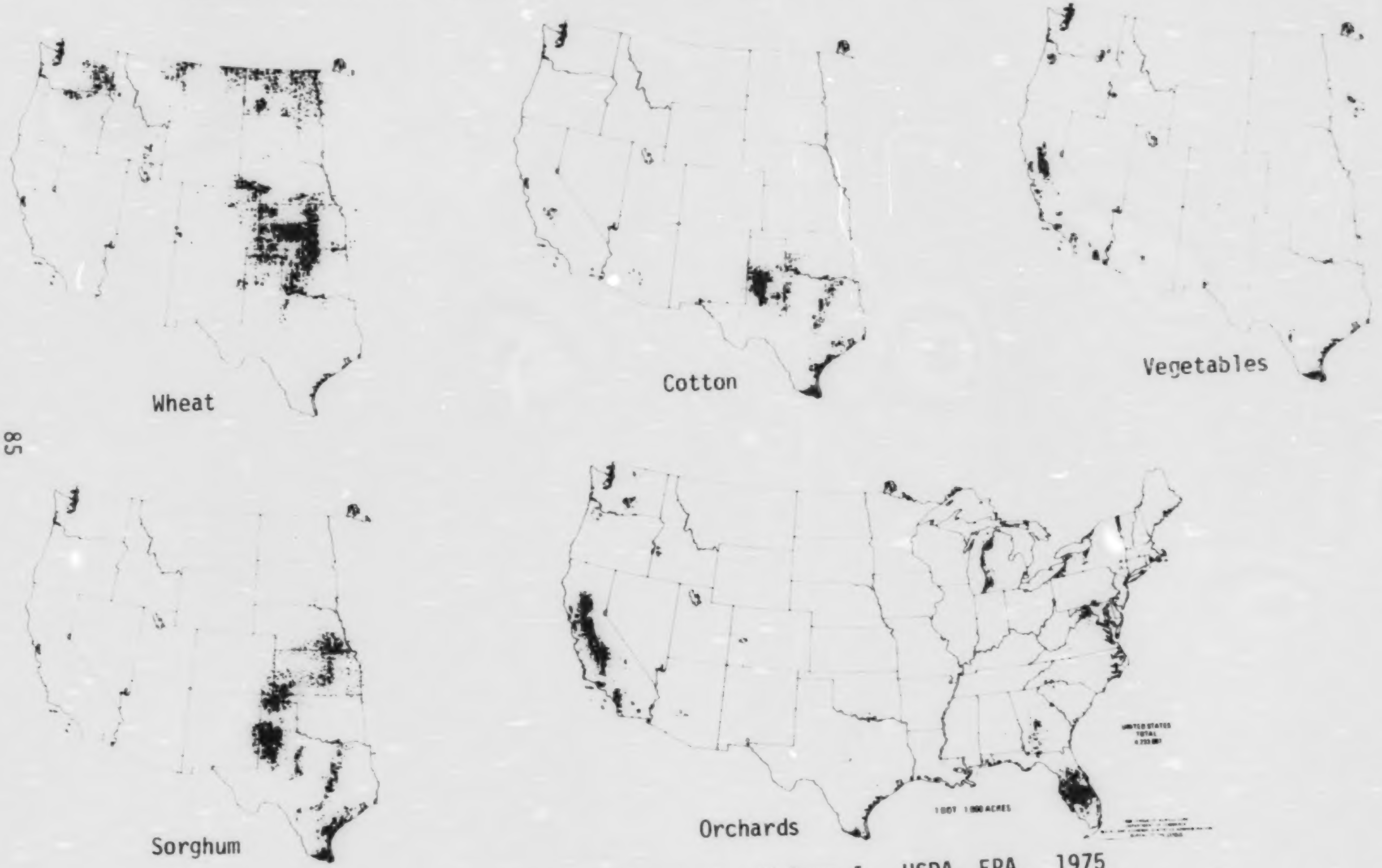
Crop production on irrigated cropland contributes, in varying degrees, to the pollution of water, air, and land. It can also cause other environmental damages to the ecology, to aesthetics, and to human health. The potential irrigated cropland pollutants include sediment, pesticides, fertilizer, animal and municipal wastes, crop residue, and irrigation return flow salinity. These are considered major pollutants, and they are variously transported to water and air. They contribute to water pollution through direct runoff, sediment movement, percolation, and to a small extent by wind erosion. They contribute to air pollution by wind erosion and volatilization.

Significant pollution problems are posed both to surface water (streams and rivers) and ground water by pollutants from irrigated cropland. The major surface water pollutant (by volume) is sediment resulting from soil erosion. While soil erosion per se is not a major concern in irrigated cropland, the sediment yielded appreciably increases sediment loading above the background loading and also carries other pollutants such as pesticides and fertilizers.

Fertilizer and pesticide pollution is receiving growing concern, for these pollutants affect not only surface but also ground water. Fertilizer pollution problems can be expected to occur in those geographical areas having considerable cropland acreage receiving high rates of application. Exhibit VII-6 shows these areas for sorghum, vegetables, cotton, wheat and orchard cropland. Irrigated wheat cropland receiving some of the highest rates is located principally in the western parts of Kansas, Oklahoma, and Texas and in the eastern part of Washington. The major pollution problems from the fertilization of irrigated cotton and sorghums occur primarily in Texas. The Imperial Valley of California and the southern part of Texas face major problems stemming from irrigation of orchard and vegetable cropland.

Commercial fertilizers contain the plant nutrients nitrogen (N), phosphorus (p), and potassium (K). Since there is no evidence that potassium causes any significant problems in water pollution, the only two nutrients having environmental implications are nitrogen and phosphorus. Nitrate nitrogen, soluble in water, pollutes surface waters through direct runoff and ground water through percolation. Phosphorus, relatively insoluble, is of concern primarily for surface water pollution. Attached to sediment, it enters the water via sediment movement.

Exhibit VII-6. Irrigated cropland receiving high rates of fertilization.


Wheat
Cotton
Vegetables
Sorghum
Orchards
1 DOT 1,000 ACRES
UNITED STATES TOTAL

Source: Control of Water Pollution from Cropland. Volume I. USDA, EPA. 1975

Although commercial fertilizers provide the major source of plant nutrients, animal wastes (manure) provide a significant source in feedlot and dairy farm areas. Manure can pose significant problems in local areas when high rates per acre are applied. Exhibit VII-7 shows the major areas of feedlot and dairy farm concentrations.

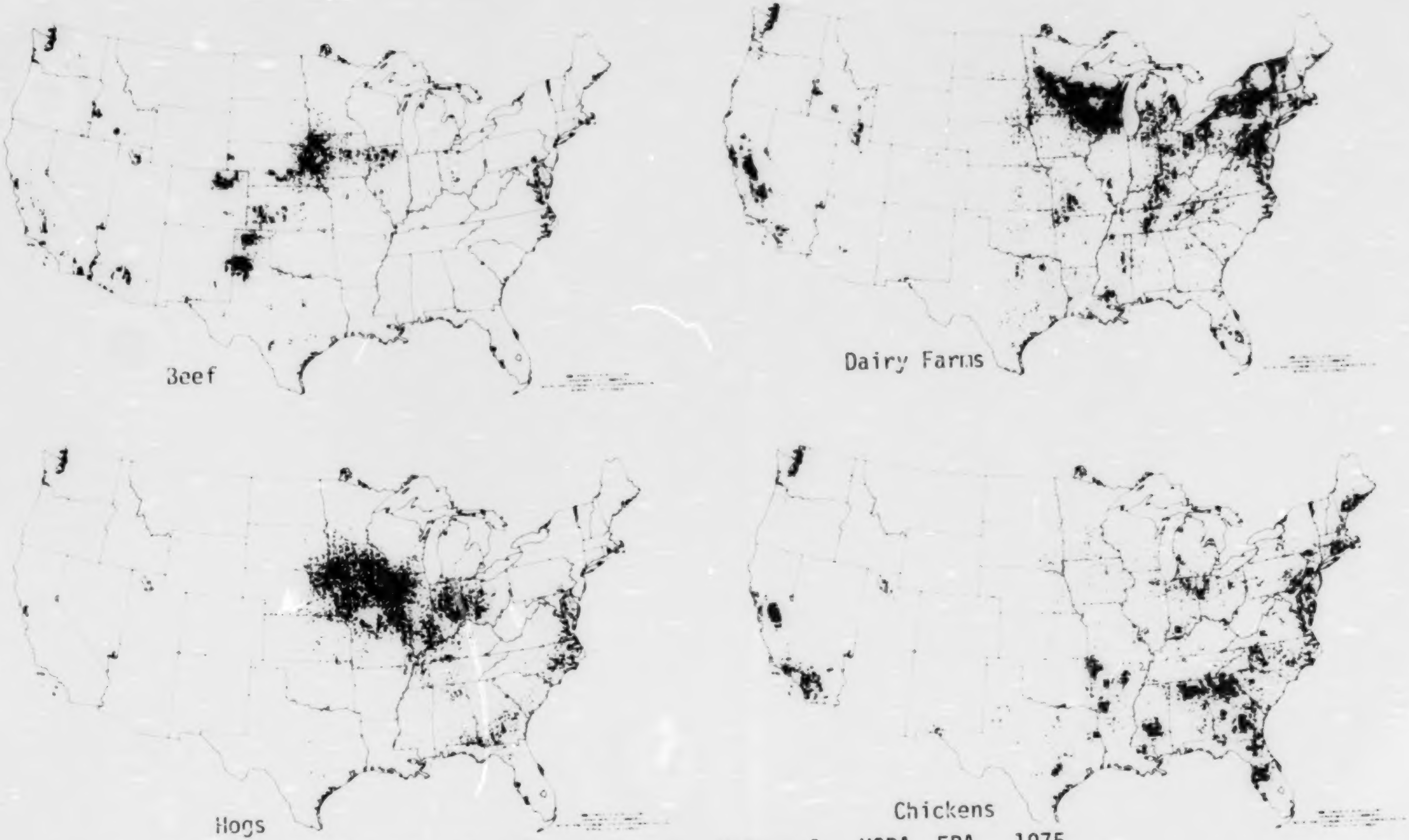
Manure from beef feedlots can be expected to pose major pollution problems on irrigated cropland in the Texas Panhandle and in the eastern part of Colorado. Milk cow and poultry wastes present pollution problems to irrigated cropland primarily in the Imperial Valley.

Pollutants from pesticides, while minor in terms of total volume, have been receiving increasing public interest because of the toxicity and persistence of some. Pollution problems can be expected in those areas in which cropland receives high rates of application, but there is little documentation to indicate any significant national problems. Exhibit VII-8 shows the cropland areas treated with herbicides and insecticides in 1969. These pesticides were used chiefly on irrigated cropland in the Texas Panhandle, in the Imperial Valley of California, and in Washington. Although there has been no comprehensive documentation of the pesticide runoff on irrigated cropland, a number of research projects investigating runoff on limited scales have been conducted. These projects lead to the general conclusion that runoff is less than 5 percent of the amount applied.

Irrigation return flow salinity is a significant pollutant to surface water, ground water, and soil composition. The major components of salinity [salinity = the presence of dissolved solids in the water] include water-soluble compounds of the cations calcium, magnesium, sodium, and potassium and of the anions carbonate, bicarbonate, sulfate, and chloride. Minor amounts of iron, aluminum, manganese, and other cations are also present. Salinity, or salt pickup, occurs during normal irrigation practices as a portion of the irrigation water is carried to the subsoil or ground water. This percolating water, carrying with it salts accumulated in the root zone, can move up or down in the soil profile. Some is eventually collected by drains and returned to the main stream, and the salt concentration of the irrigation return flow may be two to five times that of the initial irrigation water. Another fraction accumulates on or near the surface.

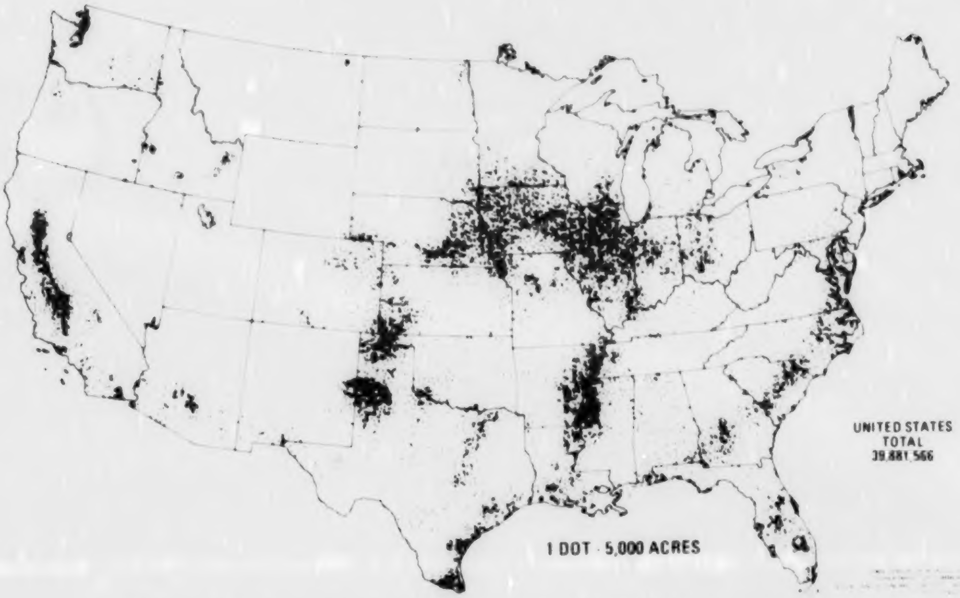
Salinity problems are associated principally with cropland irrigated with surface water. They are particularly acute in California, Arizona, and New Mexico where over 50 percent of the water supplied to irrigated cropland stems from surface sources and in Montana, Wyoming, Washington, Utah, and North Dakota where about 90 percent of the irrigation water is from such sources.

Exhibit VII-7. Concentrations of feedlots which include dairy farms, beef, hogs, and chickens.

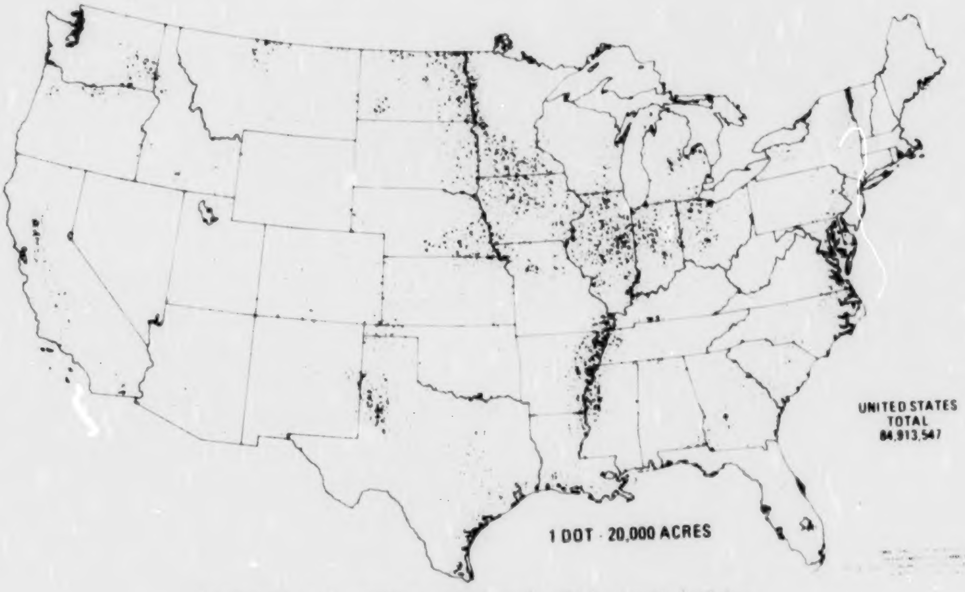

Beef
Dairy Farms
Hogs
Chickens

Source: Control of Water Pollution from Cropland. Volume I. USDA, EPA. 1975

Exhibit VII-8. Croplands treated with pesticides and herbicides: 1969


UNITED STATES
TOTAL
39,881,566
1 DOT 5,000 ACRES

Acreage of non-hay crops treated with insecticides


UNITED STATES
TOTAL
84,913,547
1 DOT 20,000 ACRES

Acreage of crops treated with herbicides

Source: Control of Water Pollution from Cropland. Volume I. USDA, EPA. 1975.

2. Trends and Environmental Implications

Crop production on irrigated cropland encompasses a wide variety of management practices which differ considerably among crops and among geographical regions. Although the entire production system must be viewed to assess the total impact of this cropland on the environment, each of the practices can be examined to determine its specific environmental implications.

Trends. The general relationships of these management practices within the production system are illustrated in Exhibit VII-9. Included in the system are the management practices (resource management), resource inputs, technological developments, and the production outputs (including residuals generated). This system provides the framework in which the trends in crop production on irrigated cropland have been identified. Those trends discussed and analyzed are listed in Exhibit VII-10 and subsequently described in Exhibit VII-11. The specific trends have been grouped under the following major practices: (1) crop management, (2) soil-water management, (3) nutrient management, and (4) pest control. The trends, expressed in brief terms, implicitly reflect the adoption or the increasing utilization of the specific management practice.

Environmental Implications. In the analysis of the trends, a matrix (Exhibit VII-12) was developed so that the potential interactions between the specific practices and the generation of pollutants could be examined. These interactions represent changes that would have occurred in the amount of pollutants produced on a representative unit of production (acre of irrigated cropland) had it been cropped under conventional practice and conditions prevalent in 1976. The interactions were denoted by pluses (+) and minuses (-) [+ represents a decreasing effect or beneficial environmental impact; - denotes an adverse environmental impact]. The matrix not only illustrates the interactions between specific practices and pollutants generated, but also represents, in certain cases, logical interactions among practices. For example, the primary impact of no-till planting is a decrease in soil sediment. However, no-till requires an attendant increase in the use of pesticides. Consequently, this increase was reflected in the matrix as an interaction between the practice of no-till and the generation pesticide pollutants. Based on a review of the interactions displayed in the matrix, general conclusions were drawn concerning trends and environmental implications.

(a) Crop management trends. The principal trends projected in crop management involve conservation tilling, crop sequencing, and seed/plant improving. In conservation tilling (201), the increased utilization of no-tillage and reduced tillage practice will have the following major impacts on both water and soil quality: (1) the reduction in soil disturbance and the greater cover of residue on the cropland will impede soil erosion by reducing runoff, and this, in turn, will reduce the sedimentation of the surface water. (2) Although direct runoff can be expected to decrease, percolation and leaching will increase since a greater part of the moisture will be retained on the cropland. (3) With the increased utilization of conservation tilling, a greater infestation of cropland by insects and diseases will occur; consequently, increased applications of pesticides will be required and will result in a greater potential for pesticides runoff. (4) Conservation tilling may also result in increased nutrient runoff, however, both because of the large amounts of organic matter in the cropland and the prospectively greater applications of fertilizers. (5) Although total runoff will be decreased, nitrogen concentration in that runoff may be increased. (6) The increased percolation, will increase the potential for nitrates entering ground water. (7) Because of the reduction in sedimentation, movement of phosphorus to surface water will be substantially decreased. Thus, the overall implication of conservation tillage will be the reduction of the potential for water and land pollution.

Exhibit VII-9. Crop production system: Irrigated Cropland

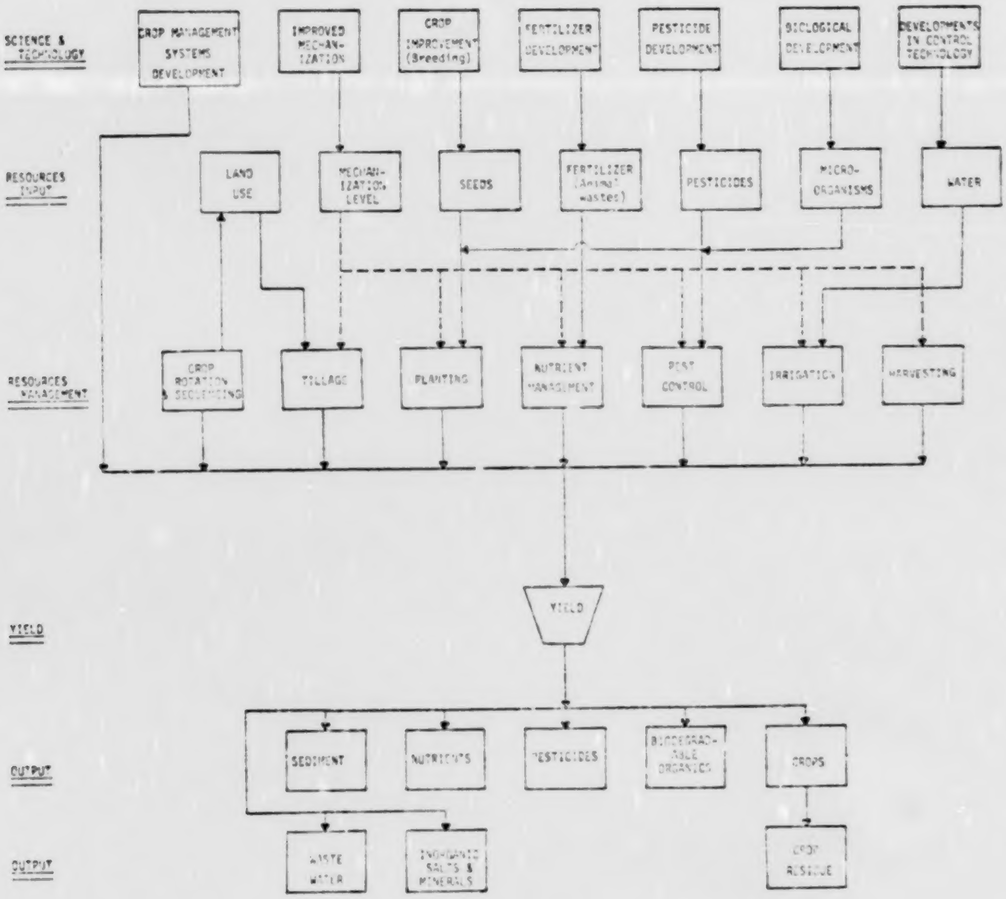

SCIENCE & TECHNOLOGY
CROP MANAGEMENT SYSTEMS DEVELOPMENT
IMPROVED MECHANIZATION
CROP IMPROVEMENT (Breeding)
FERTILIZER DEVELOPMENT
PESTICIDE DEVELOPMENT
BIOLOGICAL DEVELOPMENT
DEVELOPMENTS IN CONTROL TECHNOLOGY
RESOURCES INPUT
LAND USE
MECHANIZATION LEVEL
SEEDS
FERTILIZER (Animal wastes)
PESTICIDES
MICRO-ORGANISMS
WATER
RESOURCES MANAGEMENT
CROP ROTATION & SEQUENCING
TILLAGE
PLANTING
NUTRIENT MANAGEMENT
PEST CONTROL
IRRIGATION
HARVESTING
YIELD
YIELD
OUTPUT
SEDIMENT
NUTRIENTS
PESTICIDES
BIODEGRADABLE ORGANICS
CROPS
OUTPUT
WASTE WATER
INORGANIC SALTS & MINERALS
CROP RESIDUE

Exhibit VII-10. Environmentally-related agricultural trends: Irrigated Cropland

CROP MANAGEMENT TRENDS

201. CONSERVATION TILLING
    a. No-tillage
    b. Reduced tillage: chisel, plowing, undercutting, chemical

202. CROP SEQUENCING
    a. Mono-crop sequencing
    b. No-meadow crop sequencing
    c. Relay cropping
    d. Double cropping

203. SEED/PLANT IMPROVING (Genetic development)
    a. Weather resistance
    b. Salt tolerance
    c. Production efficiency

SOIL WATER MANAGEMENT TRENDS

204. RUN-OFF AND EROSION CONTROLLING
    a. Contour farming: contour planting, contour-strip cropping
    b. Using terraces and
    c. Using winter cover crops
    d. Optimizing time of operations; tillage, planting
    e. Using narrow rows
    f. Using chemical erosion-control agents

205. WIND-EROSION CONTROLLING
    a. Using strip-cropping (with furrow and solid set sprinkler irrigation)
    b. Using barrier rows (crops)
    c. Using free windbreaks

206. USING SPRINKLER IRRIGATION

207. USING DRIP OR TRICKLE IRRIGATION

208. REDUCING WATER APPLICATION
    a. Using furrow basin
    b. Using large sprinklers
    c. Applying less frequently
    d. Recycling and controlling tailwater

Exhibit VII-10 (continued)

209. DIRECTLY MONITORING IRRIGATION NEEDS
    a. Measuring soil moisture content
    b. Remote sensing at plant or soil water stress

NUTRIENT MANAGEMENT TRENDS

210. IMPROVING SOIL-PLANT ANALYSIS
    (Crop logging)

211. METHODS OF NUTRIENT APPLYING
    a. Using foliar fertilization
    b. Using fertigation
    c. Using multiple applications
    d. Using aerial and floater vehicle application
    e. Using fall fertilization
    f. Using liquid fertilizers

212. USING ALTERNATIVE NUTRIENT SOURCES
    a. Using animal wastes
    b. Using municipal treatment plant wastes
    c. Using green manure crops

213. DEVELOPING BIOLOGICAL NITROGEN-FIXATION SOURCES
    a. Developing legume sources
    b. Developing non-legume sources

214. DEVELOPING IMPROVED FERTILIZERS

    a. Developing controlled-release fertilizers
    b. Developing high nitrogen content fertilizers
    c. Developing high phosphorus content fertilizers

PEST CONTROL TRENDS */

215. USING SCOUTING
    a. Using surface scouting
    b. Using remote sensing scouting

216. IMPROVING PESTICIDE APPLICATION METHODS AND TIMING
    a. Improving aerial application
    b. Improving floater vehicle application
    c. Developing fertilizer and pesticide dual application

    d. Improving pesticide placement

217. DEVELOPING RESISTANT CROPS
    a. Developing disease resistant crops
    b. Developing insect and nematode resistant crops
    c. Developing bird resistant crops

218. DEVELOPING NEW PESTICIDES
   a. Developing micro-encapsulated pesticides
   b. Developing systemic pesticides
   c. Developing surfactants for herbicides
   d. Developing bio-degradable pesticides
   e. Developing alternative formulations

219. DEVELOPING BIOLOGICAL CONTROLS
   a. Developing juvenile hormones
   b. Developing pheromones
   c. Developing sterile males
   d. Developing predators and parasites

220. DEVELOPING INTEGRATED CONTROLS
(i.e., chemical-biological-mechanical)

RESOURCE USE TRENDS

221. USING INCREASED RATES AND AMOUNTS OF CROP PRODUCTION INPUTS
   a. Using commercial fertilizers
   b. Using other nutrient sources: livestock wastes, municipal sludges
   c. Using chemical pesticides: herbicides, insecticides, fungicides, rodenticides, etc.
   d. Using energy: petroleum products, electricity, sunlight
   e. Using new cropland (including set-aside lands)

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[*] See Subsection C-2: Trends and Environmental Implications, for changes in trend groupings by the evaluation workshop.

Exhibit VII-11. Description of environmentally-related trends and developments: Irrigated Cropland Production

CROP MANAGEMENT TRENDS

201. CONSERVATION TILLING - general reduction in cropland soil disturbance
    a. No till plant: seeding without pre-planting tillage
    b. Reduced tillage: weed control and soil breaking with limited soil inversion

202. CROP SEQUENCING - cropping patterns
    a. Mono-cropping: successive planting of one crop on the same plot of land
    b. No-meadow: eliminates pastures or meadows from rotation sequence
    c. Relay cropping: planting the second crop before the first crop is harvested
    d. Double cropping: planting the second crop after the first crop is harvested in the same growing season

203. SEED/PLANT IMPROVING
    a. Weather resistance: plants genetically developed to withstand winds, drought, etc.
    b. Salt tolerance: developing plants capability to produce in a saline environment
    c. Production efficiency: genetic development of plants which utilize nutrients and sunlight more efficiently and have desired growth characteristics of root development, growth and maturity.

SOIL WATER MANAGEMENT TRENDS

204. Runoff and Erosion Control
    a. Contour farming: farming operations are performed according to the land evaluations
    b. Terracing: soil embankments which slow the downhill flow of surface waters
    c. Cover crops: stubble mulching and grassed waterways to slow runoff flow.
    d. Optimizing time of operation: performing farm operations to minimize the time period that the soil is bare
    e. Narrow rows: reducing the distance between adjoining rows of seeded crops
    f. Chemical erosion-control: Chemical agents applied to reduce soil erosion

Exhibit VII-11 (continued)

205. WIND-EROSION CONTROLLING
  a. Strip cropping: dividing the field in alternate narrow bands of crop and fallow land
  b. Barrier rows: use of taller crops to act as wind breaks
  c. Wind breaks: planting trees and shrubs to reduce the effect of the wind and soil loss

206. SPRINKLER IRRIGATION - application of water to crops dispersing droplets through the air

207. USING DRIP OR TRICKLE IRRIGATION - application of water to crops by dispersing through subsurface delivery systems

208. REDUCING WATER APPLICATION
  a. Furrow basins: small earth dams used to impound water in furrows
  b. Sprinklers: dispersing irrigation water droplets through the air
  c. Limited application: reducing irrigation frequency to climinate over-irrigation
  d. Recycling and controlling tailwater: using irrigation water runoff for application to other crops and improving irrigation water management.

209. DIRECTLY MONITORING IRRIGATION NEEDS
  a. Measure soil moisture content: direct field probes
  b. Remote sensing of plant and water stress: by using satellite information

NUTRIENT MANAGEMENT TRENDS

210. IMPROVING SOIL-PLANT ANALYSIS (crop logging) - monitoring nutrient uptake, soil nutrients available, and plant condition to provide information to adjust fertilizer rates, timing, and cultural practices

211. METHODS OF NUTRIENT APPLYING
  a. Foliar fertilization: applying fertilizer as a spray so that nutrients are taken up through the leaves of the plant
  b. Fertigation: fertilizer application through irrigation systems
  c. Multiple application: fertilizer is applied more than one time to realize optimum growth and crop production
  d. Aerial and floater application: fertilizer is applied via airplane, helicopter, or by ground machines equipped to traverse wet or dry ground with limited soil compactions

Exhibit VII-11 (continued)

- e. Fall fertilization: application of fertilizer during the fall season prior to the crops primary growing season
- d. Liquid fertilizer: application of nutrients as a liquid to enhance crop production.

212. USING ALTERNATIVE NUTRIENT SOURCES
    - a. Animal wastes: solid and liquid wastes from livestock feedlots contain nutrients and organic matter.
    - b. Municipal treatment plant wastes: use of municipal wastes as a source of nutrients
    - c. Green manure crops: crops grown for the intended purpose of incorporating immature plants into the soil structure

213. DEVELOPING BIOLOGICAL NITROGEN-FIXATION SOURCES
    - a. Legumes: plants capable of fixing atmospheric nitrogen and accumulating it in root nodules
    - b. Non-legume: soil microbacterial populations that are able to fix nitrogen from the air.

214. DEVELOPING IMPROVED FERTILIZERS
    - a. Controlled-release: chemical inhibitors to delay nitrification, leaching etc. are added to fertilizers
    - b. High nitrogen content: use ammonia to supply a high concentration of nitrogen
    - c. High phosphorus content: use of polyphosphates to increase phosphorus content about 50 percent more than ordinary fertilizers

PEST CONTROL TRENDS */

215. USING SCOUTING
    - a. Surface: determine types of pests and potential crop damage by visual inspection
    - b. Remote sensing: insect populations and locations are determined by satellite information

216. IMPROVING PESTICIDE APPLICATION METHODS AND TIMING
    - a. Aerial application: new methods to decrease pesticide drift during application by increasing and homogeneous partical size
    - b. Floater vehicle: can be used on wet soil for timely application
    - c. Dual application: herbicides, pesticides, and liquid fertilizer simultaneous application through irrigation water
    - d. Pesticide placement: using the most effective and efficient manner for applying pesticides

Exhibit VII-11 (continued)

217. DEVELOPING RESISTANT CROPS
  - a. Disease resistant: genetically developing plant species capable of resisting specific diseases
  - b. Insect and nematode resistant: genetically developing plant species capable of resisting selected insects and nematodes
  - c. Bird resistant: genetically developing plant species that are less accessible to feeding bird populations

218. DEVELOPING NEW PESTICIDES
  - a. Micro-encapsulated pesticides: pesticides in microcapsule form that slowly release the pesticide over a longer time period
  - b. Systemic pesticides: pesticide compounds that are absorbed by the plant which make it toxic to pests
  - c. Surfactants: chemical materials which enhance the adsorption and absorbtion properties of herbicides
  - d. Bio-degradable pesticides: chemicals which are affective against pests and are decomposable by the environment with limited persistence.
  - e. Alternative formulations: different methods combining chemicals which are effective against pests.

219. DEVELOPING BIOLOGICAL CONTROLS
  - a. Juvenile hormones: Hormonal compounds capable of preventing normal development and maturation of insects
  - b. Pheromones: chemical compounds containing organophosphorus insecticide used to selectively attract insects.
  - c. Sterile males: release sexual sterile insects to decrease or control insect population
  - d. Predators and parasites: use of natural enemies, fungi, virsuses, bacteria, to control insect populations

220. DEVELOPING INTEGRATED CONTROLS - integrating chemical, biological, and mechanical treatment methods to achieve desired control over cropland production

RESOURCE USE TRENDS

221. USING INCREASED RATES AND AMOUNTS OF CROP PRODUCTION INPUTS - increasing demands for cropland production will affect the quantity of fertilizer, animal and municipal wastes, chemicals, energy and land used for food production

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*/ See subsection C-2: Trends and Environmental Implications, for changes in trend groupings by the evaluation workshop.

Exhibit VII-12. Environmentally-related trends: Irrigated Cropland

TRENDS	Potential Contribution to Pollution--Major Pollutants																
	Surface Water						Ground Water			Air		Land					
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	heavy metals	Pesticide residues	Biodegradable organics
CROP MANAGEMENT TRENDS																
201. CONSERVATION TILLING	+	+	+	-	0	-	-	-	0	0	+	+	0	0	-	-
a. No-tillage	+	+	+	-	0	-	-	-	0	0	+	+	0	0	-	-
b. Reduced tillage: chisel plowing, undercutting, chemical	+	+	+	-	0	-	-	-	0	0	+	+	0	0	-	-
202. CROP SEQUENCING	-	-	-	-	0	0	0	-	0	0	-	-	0	0	-	0
a. Mono-crop sequencing	-	-	-	-	0	0	0	-	0	0	-	-	0	0	-	0
b. No-meadow crop sequencing	-	-	-	-	0	-	+	-	0	0	-	-	0	0	-	-
c. Relay cropping	+	+	+	+	0	-	-	-	0	0	+	+	0	0	-	-
d. Double cropping	+	+	+	+	0	-	-	-	0	0	+	+	0	0	-	0
203. SEED/PLANT IMPROVING (Genetic development)	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	-
a. Weather resistance	+	0	+	0	0	-	0	0	0	0	+	+	0	0	0	-
b. Salt tolerance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c. Production efficiency	+	+	+	0	0	-	-	0	0	0	+	+	0	0	0	-
SOIL WATER MANAGEMENT TRENDS																
204. RUN-OFF & EROSION CONTROLLING	+	+	+	+	0	+	-	-	-	0	+	+	0	0	-	-
a. Contour farming: contour planting, contour-strip cropping	+	+	+	+	0	+	-	-	-	0	+	+	0	0	-	-
b. Using terraces & grass waterways	+	+	+	+	0	+	-	-	-	0	+	+	0	0	-	-
c. Using winter cover crops	+	+	+	+	0	+	-	-	-	-	+	+	0	0	-	-
d. Optimizing time of operation: tillage, planting	+	+	+	+	0	0	+	+	+	0	+	+	0	0	+	0
e. Using narrow rows	+	+	+	+	0	-	+	+	0	-	+	+	0	0	+	-
f. Using chemical erosion-control agents	+	+	+	+	0	0	-	-	-	0	+	+	0	0	-	0
205. MOISTURE CONSERVING (STORAGE)	-	0	-	+	-	+	-	+	-	+	-	-	-	0	0	-
a. Fallow cropping: moisture storage, salt-seeps	-	0	-	+	-	+	-	+	0	+	-	-	-	0	0	-
b. Using evapo-transpiration reducing agents	+	0	+	0	0	0	-	0	-	0	+	+	+	0	0	0

Exhibit VII-12 (continued)

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
206. SPRINKLER IRRIGATION	+	+	+	+	+	0	+	+	+	0	+	+	-	0	-	0
207. USING DRIP OR TRICKLE IRRIGATION	+	+	+	+	+	0	+	+	+	0	+	+	--	0	-	0
208. REDUCING WATER APPLICATION	+	+	+	+	+	0	+	+	+	0	+	+	-	0	-	0
a. Furrow basins	+	+	+	+	+	0	-	-	-	0	+	+	-	0	-	0
b. Sprinkler	+	+	+	+	+	0	+	+	+	0	+	+	-	0	-	0
c. Limited applicaton	+	+	+	+	+	0	+	+	+	0	+	+	-	0	-	0
d. Recycling and controlling tail water	+	+	+	+	+	+	-	-	-	0	+	+	-	0	-	0
209. DIRECTLY MONITORING IRRIGATION NEEDS	+	+	+	+	+	0	+	+	+	0	+	+	-	0	-	0
a. Measure soil moisture content	+	+	+	+	+	0	+	+	+	0	+	+	-	0	-	0
b. Remote sensing	+	+	+	+	+	0	+	+	+	0	+	+	-	0	-	0
211. METHODS OF NUTRIENT APPLYING	+	+	+	0	0	0	0	0	0	0	+	+	0	0	0	0
a. Foliar fertilization	+	+	+	0	0	0	+	0	0	0	+	+	0	0	0	0
b. Fertigation	+	+	+	0	0	0	0	0	0	0	+	+	0	0	0	0
c. Multiple application	-	-	-	0	0	0	-	0	0	0	-	-	0	0	0	0
d. Aerial and floater application	+	+	+	0	0	0	+	0	0	0	+	+	0	0	0	0
e. Fall fertilization	+	+	+	0	0	0	-	0	0	0	-	+	0	0	0	0
d. Liquid fertilizer	+	+	+	0	0	0	0	0	0	0	+	+	0	0	0	0
212. USING ALTERNATIVE NUTRIENT SOURCES	+	-	-	0	0	-	-	0	0	-	-	+	0	0	0	0
a. Using animal wastes	+	-	-	0	0	-	-	0	0	-	-	+	0	0	0	0
b. Using municipal tr eatment plant wastes	+	-	-	0	0	-	-	0	0	-	-	+	0	-	0	0
c. Using green manure crops	-	+	+	0	0	-	-	0	0	+	-	-	0	0	0	0

Exhibit VII-12 (continued)

TRENDS	Potential Contribution to Pollution--Major Pollutants																
	Surface Water						Ground Water			Air		Land					
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
213. DEVELOPING BIOLOGICAL NITROGEN-FIXATION SOURCES	+	+	0	0	0	-	+	0	0	0	+	+	0	0	0	-
a. Developing legume sources	+	+	0	0	0	-	+	0	0	0	+	+	0	0	0	-
b. Developing non-legume sources	+	+	0	0	0	-	+	0	0	0	+	+	0	0	0	-
214. DEVELOPING IMPROVED FERTILIZERS	0	+	+	0	0	0	+	0	0	0	0	0	0	0	0	0
a. Developing controlled-release fertilizers	0	+	+	0	0	0	+	0	0	0	0	0	0	0	0	0
b. Developing high nitrogen content fertilizers	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0
c. Developing high phosphate content fertilizers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PEST CONTROL TRENDS																
215. USING SCOUTING	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
a. Using surface scouting	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
b. Using remote sensing scouting	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
216. IMPROVING PESTICIDE APPLICATION METHODS AND TIMING	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
a. Improving aerial application	0	0	0	+	0	0	0	0	0	0	0	0	0	0	+	0
b. Improving floater vehicle application	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
c. Developing fertilizer and pesticide dual application	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
d. Improving pesticide placement	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
217. DEVELOPING RESISTANT CROPS	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
a. Developing disease resistant crops	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
b. Developing insect and nematode resistant crops	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
c. Developing bird resistant crops	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0

Exhibit VII-12 (continued)

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sedi-ment	Nitro-gen	Phos-phorus	Pesti-cides	Inorganic salt and minerals	Biode-gradable organics	Nitrates	Pesti-cides	Inorganic salt and minerals	Gases	Par-ticu-lates	Soil erosion	Sa-linity	Heavy metals	Pesti-cide residues	Biode-gradable organics
218. DEVELOPING NEW PESTICIDES	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
a. Developing micro-encapsulated pesticides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
b. Developing systematic pesticides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
c. Developing surfactants for herbicides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
d. Developing bio-degradable pesticides	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
e. Developing alternative formulations	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
219. DEVELOPING BIOLOGICAL CONTROLS	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
a. Developing juvenile hormonew	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
b. Developing pheromones	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
c. Developing sterile males	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
d. Developing predators and parasites	+	0	0	+	0	0	0	+	0	0	+	+	0	0	+	0
220. DEVELOPING INTEGRATED CONTROLS (i.e., chemical-biological-mechanical)	0	0	0	+	0	0	0	+	0	0	0	0	0	0	+	0
RESOURCE USE TRENDS																
221. USING INCREASED RATES AND AMOUNTS OF CROP PRODUCTION INPUTS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
a. Using commercial fertilizers	-	-	-	0	0	-	-	0	0	-	-	-	0	0	0	-
b. Using other nutrient sources: livestock wastes, municipal sludges	-	-	-	0	0	-	-	0	0	-	-	-	0	0	0	-
c. Using chemical pesticides: herbicides, insecticides, fungicides, rodenticides	-	0	0	-	0	0	0	-	0	0	-	-	0	0	-	0
d. Using energy: petroleum products, electricity, sunlight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
e. Using new cropland (including set-aside lands)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The trends in crop sequencing (202) carry diverse implications. The mono-cropping and no-meadow rotation practices would tend to increase water and land pollution. Under mono-cropping, which increases the threat of insect and disease infestion, pesticide applications may increase. Too, mono-cropping, depending upon the type of crop involved, may increase or decrease erosion. (With row crops, the potential is somewhat increased; those crops affording better cover would decrease the overall potential.) Omitting meadows from the rotation sequence would increase erosion potential and typically require increased fertilizer application. Both of these would contribute to water and land pollution.

Although the above crop sequencing practices would affect the environment adversely, relay - and double-cropping may have indirect beneficial effects. Both of these practice may impede erosion and reduce, in many cases, fertilizer requirements on a unit of output basis, i.e., more intensive double cropping on one location may be preferred to extensive cropping on multiple locations. Slight increases in insecticide requirements would increase the potential for pesticide runoff, however.

The impacts on the environment associated with those seed/plant improvements (203) included as crop management trends would largely be indirect. These genetic developments primarily affect crop yields and such increases have minor impacts on any given acre of cropland. The most significant implication stemming from increased yields would be a decrease in the cropland required to meet a specific level of demand, and although the overall cropland requirements will continue to increase, that increase would not be as great as it would have been without the improved crops.

(b) Soil-water management trends. Trends in soil-water management include practices designed to reduce runoff and soil erosion, and to decrease wind erosion. Major trends in irrigation involve the increasing use of sprinkler and to a lesser degree dry or trickle irrigation. Erosion controls (204) such as contour farming, terracing, and the use of winter cover crops are traditional methods of stabilizing the soil. Their use continues to increase since they are recognized to be not only environmentally sound but also economically profitable. The principle feature of these practices is that they impede runoff and retard sediment movement and their environmental effect is to reduce both water and land pollution. A secondary effect is that they increase the moisture retained in the soil and percolated. This increased percolation presents a greater potential for nitrates entering the ground water.

The damages done through wind erosion (205) have been severe during such times as the drought in the 1930's and, more recently, in the 1950's. Although wind erosion is most severe in semi-arid and arid regions under irrigation, it is significant on nonirrigated cropland. Stripcropping, barrier rows, and tree windbreaks play an important role in offsetting the damages of wind erosion. Reducing wind erosion not only stabilizes the soil and reduces land pollution, but it also impedes sediment movement in active surface waters. These effects, also reduce the potential for air and water (surface) pollution.

Sprinkler irrigation (206) has been increasing significantly since World War II with the development of more efficient sprinkler, lightweight aluminum pipe, more efficient pumps, and low cost electrical power. Sprinklers are being used on all types of soil and for many crops. Their use is particularly effective on land having steep slopes and easily erodable soils and an undulating land too costly to level for surface irrigation.

The uniform distribution of water in sprinkler irrigation reduces the potential for soil erosion and facilities leaching of salts from the root zone.

Drip or trickle irrigation (207) is being used for crops grown under a wide range of conditions, but is particularly beneficial in temperate areas where irrigation is utilized to supplement moisture from rainfall during the growing season. The system finds wide application for irrigating newly planted orchards and vineyards. Drip irrigation is often more effective than other systems when used to irrigate vegetable crops (grown on raised beds) with water having a relatively high salt content since the salts are moved with the water away from the plant roots. In this type of system, a potential danger from salt accumulation in the soil exists since salts normally accumulate on the periphery of that portion of the wet soil. When moisture is extracted from the soil, a reversal in the flux of water from the periphery back into the root zone can occur. With inadequate irrigation, crops can be injured by this reverse movement of salts in saline soil conditions.

Reducing water application (208) in irrigation which is accomplished principally for economic reasons has both beneficial and adverse effects on the environment. The primary benefit involves the conservation of water resources; adding excessive moisture during irrigation not only waste water, which may be in scarce supply, but also may damage the crop. The use of farrow basins and large sprinklers, when properly used, may leach salts from the root zones and prevent salinity in the soil. On the other hand, recycling and controlling tail-water may increase problems in salinity.

Directly monitoring irrigation needs (209) is a prerequisite for the proper management of water practices discussed above concerning reduced irrigation. It both conserves water and promotes better crop yield.

(c) Nutrient management trends. In nutrient management, trends with environmental implications include new methods in applying fertilizer, alternative nutrient sources, biological nitrogen-fixation, and certain technological developments. New soil plant analysis techniques (210) for analyzing nutrient requirements of the soil and plants are being developed and utilized. Widespread application of such analyses are expected in the future with benefits not only to crop yield but also to the environment. The significant effect of these analyses is a potential reduction in unnecessary applications of fertilizers and an associated reduction in nutrient runoff.

A number of innovations involving methods of application (211) of commercial fertilizer are receiving increasing utilization. These methods are generally more efficient and cause less soil disturbance during application. Multiple applications are designed to apply the fertilizers on the cropland during times which are most beneficial for nutrient uptake by the plants; this reduces the rate of application during any one period and, consequently, lessens the potential for nutrient runoff. However, multiple applications increase, to a small degree, soil disturbance with a resultant increase in soil erosion potential.

Fall application of fertilizer is increasing significantly. This practice has both beneficial and detrimental effects. The major benefit is that it precludes the application of fertilizer in the spring time when the ground is most vulnerable to erosion forces. On the other hand, the fertilizer remains in the soil a longer period of time before plant uptake and is subject to greater leaching. Also, through percolation, the potential for contaminating surface waters is slightly greater although there is no evidence to show that this has become a problem.

With the increasing sizes of farms, use of floaters in crop management has been increasing dramatically. The high flotation lines reduce compaction and soil disturbance and facilitate a more efficient application of fertilizers on the cropland. This reduces both problems in sedimentation and nutrient runoff. Although application of fertilizer by aircraft is relatively minor at the present, the development of high concentration and foliar types of fertilizer are expected to make this type of application more feasible. This delivery system would facilitate fertilization of cropland at the time nutrient intake was the greatest in the crops which would lessen the amounts of fertilizer subject to funoff. Additionally, there would be little disturbance of the soil with a minimum risk of soil erosion.

The use of alternative nutrient source (212) is expected to become more important in crop production. This will result primarily from disposal requirements for feedlot and municipal wastes. Cropland is often a feasible type of land on which these wastes can be disposed. Disposal is normally accomplished by spreading without incorporation; consequently nutrients contained in these wastes are often more vulnerable to runoff than those in commerical fertilizer. In addition, problems with other fertilizers may occur (an inherent difficulty is determining nutrient content of the wastes and nutrient release to the soil). Another problem may exist with heavy metals in municipal waste when applied on cropland.

The development of biological nitrogen-fixation (213) is expected to have far reaching effects on crop production in the future. Expected developments include ways of using nitrogen more efficiently, means of increasing the nitrogen fixing by plant micro-organism, and methods of improving symbiotic relationships between plants and micro-organisms. Also, genetic developments are anticipated in introducing nitrogen-fixing capabilities into non-legume plants requiring high applications of fertilizers such as corn. With such nitrogen fixation developments considerable reductions in fertilizer use would occur. This would reduce potential nitrogen runoff and leaching.

A number of developments in improved fertilizers (214) are expected to occur in the future which will have major effects on practices in nutrient management. Controlled-release fertilizers will decrease the runoff potential of nitrogen into surface water and will decrease the eutrophication in those waters that do receive nutrient loading from fertilizers applied to cropland. Additionally, this development will increase the efficiency of nutrient intake of crops which will reduce the amounts of nutrients available for runoff and leaching. Development of nitrification and leaching inhibitors will reduce problems associated with contamination of ground water. These collective trends in nutrient management (other than the increasing use of fertilizers) are expected to have an overall beneficial effect on the environment.

(d) Pest control trends. Trends in pest control include improved methods of application, scouting, developments in new pesticides, resistant crops and biological controls. Scouting (215) both surface and by remote sensing, is expected to reduce overall pesticide use by reducing the requirements for continued application in areas in which there is no threat of pest infestation.

Recent improvements in application practices (216) are expected to have beneficial effects. Improvements in aerial application techniques will reduce the amount of pesticides applied to non-target areas with a consequent reduction in pesticide use and a greater efficiency of application. These improvements will result in an increasing share of all pesticides being applied by aircraft. Also, the increasing use of floaters not only promotes efficiency in the application of pesticides, but also facilitates more timely applications. The combined effects of these improvements will be a reduction in pesticide requirements. In addition to the reductions in potential pesticide pollution, a slight reduction in soil erosion will be associated with the floater application.

Developments in dual application of fertilizer and pesticides will carry both favorable and unfavorable implications. Dual application decreases the movement of vehicles across the cropland which would lessen somewhat the disturbance of the soil. However, applications under this technique are generally not optimal for both fertilizer and pesticide use. Consequently, one of the two would be subject to runoff for a period of time greater than necessary.

Reductions in requirements for pesticides are expected with developments involving more resistant crops (217). The most beneficial developments are anticipated in the area of new improved crops resistant to pests such as insects, nematodes, birds, plus diseases. Although no dramatic developments are foreseen on the horizon, gradual improvements are envisioned which will alleviate some of the potential pesticide problems.

New pesticides (218) are being developed which will have environmental implications. They include formulations such as micro-encapsulated and systemic pesticides. The benefits from these will be derived from their greater efficiencies and the associated reduction in the total level of pesticides required. Surfactants for herbicides will facilitate more timely applications and the use of alternative pesticides. Significant impacts are expected with developments of biodegradable pesticides. These will reduce both the contamination of water (surface and ground) and of the soil itself.

Developments in biological control (219) are expected which will also have an influence on pest control practices. Potential developments involve the use of juvenile hormones, pheromones, sterile males, predators, and parasites. Both beneficial and adverse effects may occur with these developments. Biological control, in some cases, would decrease the requirements for pesticides on specific crops. This, of course, would reduce potential pollution problems: however, the introduction of these biological controls could have potential damaging effects on the environment if they affected non-targeted plants or beneficial insects.

Developing integrated controls (220) is generally the most effective system of pest control. In many cases it benefits the environment by facilitating reductions in pesticide use.

(e) Resource use trends. The trends discussed above were viewed in light of impacts which were expected to occur from changes in practices as utilized on a single unit of cropland. In many cases the practices involved changes in the use of resources such as land, pesticides, and fertilizer. Collectively these practices may be expected to have significant effects on resource use and hence on the environment, although the trends with an overriding importance are those of the increasing levels of agriculture inputs associated with the increasing demand for food. The inputs that pose significant environmental implications are fertilizers, pesticides, and land. By the year 2010, the use of fertilizers and pesticides is projected to increase well over a 100 percent while land required for nonirrigated cropland is projected to increase by fifteen percent. These increases, which constitute the basic forces on the environment, bring into focus the fundamental problems involving water, air, and land pollution. All of the practices and developments previously identified must be viewed in this perspective.

SECTION VIII

ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 3 - FEEDLOT PRODUCTION

The Feedlot Production Panel assessed and ranked the major environmentally related trends and practices in its area of expertise. The preliminary report of trends and practices in this panel area, as shown in Part C: "Background Summary", below, was the principal basis for the evaluation. The trend rankings by the Feedlot Production panel are as presented in Exhibit VIII-1; and, Exhibit VIII-2 describes briefly the top ten trends and the panel's rationale for establishing the relative rankings as indicated. Furthermore, the panel's extensiveness of use and intensiveness of effects ratings for each subtrend, which were used to develop the overall environmental rating for each trend, are presented in Exhibit III-3. These exhibits are described further below.

The Feedlot Production panel assessed, in particular, beef, dairy, swine, sheep and poultry. This panel's assessment was limited to feedlot activities, and specifically excluded livestock maintained on range or pasture land (which was considered by Panel 4--Range and Pasture Management).

The panel was comprised of five members with diverse capabilities and professional training. A wide geographic area was represented by these panelists.

Name	Representing	Specialty	U.S. Geographic Area
Raymond C. Loehr	Cornell Univ.	Agr. Engineer-Waste Disposal Treatment	Northeast
James K. Koelliker	Oregon St. Univ.	Agr. Engineer-Waste Disposal	Northwest
Dan D. Badger	Okla. St. Univ.	Agr. Economics	South-Midwest
B. P. Cardon	Arizona Feeds	Feedlot Production	West
D. E. Becker	Univ. of Ill.	Animal Science	Midwest

Exhibit VIII-1. Ranking of environmentally-related trends, 1976-2010: Feedlot Production

Rank	Trend Number [1/]	Trend	Adjusted Rating
1	308	Feedlot Sizes	15
2	319	Feedlot Design for Waste Management	12
3	317	Feedlot Residual Disposal - Solids and Liquids	10
4	313	Odor Control	9
5	318	Increased Feed Efficiency and Alternative Ration Composition	8
6	309	Geographic Concentration	8
7	316	Increasing Pesticide Use	6
8	301	Improved Animal Breeding	6
9	314	Dust and Pest Control	4
10	307	Veterinary Services	2
11	303	Improved Birth Control	<2
12	304	Alternative Bedding Material	<2
13	310	Specialization, Mechanization and Use of Multiple Man Units	<2

[1/] Numbers are those trend numbers given in Phase I, Interim Report.

Exhibit VIII-2. Descriptions of major environmentally-related trends, 1976-2010: Feedlot Production

Rank	Trend Number and Title	Adjusted Rating for 2010	Comments and Modifications
1	308 - Feedlot Sizes	15	All classes of livestock will use new and larger feedlots and they will select environmentally preferred sites and use better controls as the number of smaller feedlots decrease.
2	319 - Feedlot Design for Waste Management	12	Feedlots would continue to improve facilities and management practices which would enhance the environment. The trend will be accelerated by construction of new and larger size feedlots.
3	317 - Feedlot Residual Disposal - Solids and Liquids	10	Utilizing these management practices will reduce the environmental problems of feedlots--each class of livestock may select different practices.
4	313 - Odor Control	9	The trend towards improved waste management is most important for odor control.
5	318 - Increased Feed Efficiency and Alternative Ration Composition	8	Roughage usage is relatively unimportant in this trend, chemicals used to enhance animals utilization of feeds is of moderate importance.
6	309 - Geographic Concentration	8	Little change in geographic distribution is expected and adequate environmental controls will be utilized.
7	316 - Increasing Pesticide Use	6	There will be increased but better managed use of pesticide at the feedlot.
8	301 - Improved Animal Breeding	6	Increased use by producer is expected to achieve better feedlot gains to reduce grain consumption and wastes per unit of production.
9	314 - Dust and Pest Control	4	Small but improved fly, dust and rodent controls are foreseen.
10	307 - Veterinary Services	2	Death losses will be lower and feedlot gains will be higher, but only small changes in practices are expected.

A. Major Trend Rankings and Practices Assessments

The process of evaluating environmentally related trends for U. S. feedlots revealed that none of the trends would cause tremendous environmental changes over the next 35 years. The range of scores for any particular trend was allowed to go as low as a negative 25 and as high as a positive 25 under the chosen rating system. The range in scores for all management practices and trends was between a negative eight and a positive 15. Consequently, it appears that the trends and practices evaluated by the feedlot production panel were considered to have only moderate or minor effects on the 2010 environment.

Several generalizations could be made concerning feedlot effects on the environment in the year 2010. Feedlots in 2010 are expected to cause less environmental degradation than feedlots currently may cause. This conclusion is primarily due to the relatively new emphasis on waste handling practices as an important managerial variable. Future feedlots will consider waste management as part of their normal activity. The most important future changes which are expected to occur are that the size distribution of feedlots is expected to shift towards larger lots and the land base associated with the feedlots is expected to decline. This implies that feedlots of the future will be less likely to be of the farmer-feeder type. In addition, trends which reduce the quantity of feedlot wastes are considered about as equally important as trends which improve waste disposal techniques.

All classes of livestock are expected to utilize new and larger feedlots. This expansion in feedlot size was expected to occur only at environmentally preferred sites where surface water runoff and odor problems can be minimized. Feedlots are expected to adjust their facilities either as they expand or as they attempt to comply with environmental regulations. Surface water runoff control facilities and total confinement facilities are expected to be more numerous.

The complete feedlot panel ratings are shown in Exhibit VIII-3. The 1976, 1985, and 2010 extensiveness of use in ratings of all subtrends are included. The intensiveness ratings were determined for the year 2010 only; they are also included in Exhibit VIII-3.

The three feedlot trends which were expected to have the greatest environmental effect are:

1. Feedlot Sizes (308)
2. Feedlot Design for Waste Management (319)
3. Feedlot Residual Disposal - Solids and Liquids (317)

Exhibit VIII-3. Environmental ratings of ten trends and associated practices: Feedlot Production

Rank	Trend No.	Trend and Sub-Trend	Extensiveness Trend Rating			Intensiveness Rating
			1976	1985	2010	2010
1	308	Size of Feedlots				
		a. Beef	3	4	5	+3
		b. Dairy	2	3	4	+3
		c. Swine	3	4	5	+3
		d. Sheep	3	3	3	+3
		e. Poultry	4	5	5	+3
2	319	Feedlot Design for Waste Management				
		a. Open lot	2	2	2	-2
		b. Dry lot	3	2	2	-1
		c. Total confinement	2	3	4	+2
		d. Retention ponds	1	2	4	+2
		e. Diversion terraces	1	2	4	+2
		f. Settling basins	1	2	4	+1
		g. Lagoons	1	2	2	-1
		h. Oxidation ditch	1	1	1	+1
		i. Storage pit	2	3	4	+1
3	317	Feedlot Residual Disposal - Solids and Liquids				
		a. Daily disposal	2	2	2	+1
		b. Temporary storage of solids	5	5	5	+2
		c. Off-site disposal of solids	2	3	4	+3
		d. On-site disposal of solids	4	3	2	+3
		e. Refeeding of solids	1	1	-	+3
		f. Liquids disposal	1	2	3	+3
4	313	Odor Control				
		a. Feedlot animals	1	1	2	+2
		b. Waste management	2	3	4	+3
5	318	Increased Feed Efficiency and Ration Composition Adjustments				
		a. Ruminants	5	5	5	+2
		b. Non-ruminants	3	3	4	+2
		c. Roughage usage	1	2	2	-2
		d. Concentrate usage	4	4	4	-2
6	309	Geographic Concentration				
		a. Beef	4	4	4	+2
		b. Dairy	4	4	4	+2
		c. Swine	4	4	4	+2
		d. Sheep	4	3	3	+2
		e. Poultry	4	4	4	+2
7	316	Increasing Pesticide Use	2	3	4	+2
8	301	Improved Animal Breeding				
		a. Artificial insemination	2	3	4	+1
		b. Cross breeding	3	4	5	+1
		c. Breed selection	1	2	2	+1
9	314	Dust and Pest Control Improvement				
		a. Feedlot flies	1	1	2	+2
		b. Rodents and dust	2	3	3	+2
10	307	Veterinary Services				
		a. Prenatal immunization	1	1	1	+1
		b. Vaccines and antibiotics	4	4	4	+3
		c. Consulting veterinary	2	2	2	+1

These three trends were expected to be inextricably woven together in their development. As feedlots increase in size, the expanded portion of a feedlot or any new facility is expected to incorporate recommended facility designs and to utilize alternative residual disposal methods. Although these three trends could be viewed as separate and distinctly different, it was expected by the panel members that the three trends will develop together.

B. Environmental Implications of Major Trends and Practices

Each of the major trends in feedlot production, as determined by Panel 3, are summarized below. Background descriptions and definitions of these trends, which served as the basis for the workshop's evaluations, are included for reference in Part C: "Background Summary", as needed.

Feedlot Sizes (308). The trend toward larger feedlots, generally only now beginning, will have the most important environmental implication for feedlot production. Only a moderate beneficial effect is expected to occur as feedlots increase in size. Beef, dairy, and swine feedlots are considered to be moderate in size-extensiveness, but by 1985 the trend will be important in extensiveness. Sheep feedlots are not expected to change substantially in size, and poultry facilities are almost through their trend towards larger sizes.

The feedlot panel deliberated between evaluating the size trend by the number of feedlots or by the quantity of production from those feedlots. The decision was to evaluate this trend relative to the number of lots rather than to the proportion of production from each size of feedlot.

Increased feedlot size was considered the most environmentally important trend because of the adjustments which it will require. As feedlots increase in size, their economies are generally enhanced in two ways. First, their capital outlay per head for abatement facilities is considerably less, about one-fourth, for a large (1000+) feedlot as compared to a smaller (200-500 head) feedlot. Second, their financial resources are also greater. Larger feedlots will then use a smaller proportion of their financial resources to obtain proper waste facilities.

Additionally, as feedlots increase in size, they will do so in environmentally preferred locations. Producers have been made aware of the possibility of legal problems and the associated financial risks of locating or expanding feedlot facilities near streams and population centers. Over time, as current producers retire and as environmental regulations and enforcement procedures are developed, feedlots located in environmentally sensitive areas will phase out of production.

Feedlot Design for Waste Management (319). This particular trend was derived from a combination of preliminary report trends 306, 311, and 312 (see, Part C), including those for housing facilities, feedlot runoff control structures, and several waste handling methods. These are separate variables which management may combine in several ways, and since no precise logical separation of these variables seems appropriate, the panel combined them into one trend. The use of open and drylot 1/ feedlot facilities were expected to remain at current use levels or decline slightly between 1976 and 2010. Continued use of open lots and drylots will cause a minor adverse impact on the environment; however, legal statutes and pollution control technologies will importantly affect the trend.

Totally confined feedlots are expected to increase from a limited use level to a relatively important use level by 2010; however, considerable controversy existed among the panel members over the environmental implications of totally confined feedlot facilities. A trend toward total confinement facilities is considered beneficial since feedlot runoff potential should be reduced. The adverse environmental aspect of this trend was concerned primarily with totally confined swine facilities. Air degradation due to odors was not completely assessed, but it was generally thought to be caused by improper management practices. It was not determined whether the management practices associated with the totally confined hog facility were constrained by managements knowledge of proper operating procedures or by other factors such as limited land disposal opportunities due to crop production or legal regulations.

The use of runoff control facilities such as settling basins, retention ponds and diversion terraces was relatively limited in 1976. By 1985, the number of feedlots using these facilities will increase from a minor use level to a limited use level, and by 2010 their use would be relatively important. This predicted growth is consistent with that for open and drylot facilities and the assumption of enforced legal statutes.

Other waste handling facilities such as lagoons and oxidation ditches will be adopted by relatively few feedlots. The use of storage pits should double by 2010, primarily by swine feedlots.

Feedlot Residual Disposal - Solids and Liquids (317). The proper and effective use of waste disposal methods including those other than the traditional waste handling practices are expected to cause some improvement in the environment.

1/ See Part C: "Background Summary", for definitions of management variables and practices.

Three general predictions about solid waste handling practices resulted from the panel discussions. The use of daily and temporary storage [1/] of solid wastes will not change over the next 35 years. The major change expected in solid waste disposal is that off-site or off-farm disposal and it will be important in 2010. Conversely, on-site disposal would be subsequently reduced comparably. Refeeding of animal wastes is considered of very minor importance today and in 1985, but by 2010, refeeding will be of moderate importance for feedlots.

Since it was assumed that legal requirements will effectuate the proper disposal of wastes, the environmental effect of this trend is definitely beneficial. (This trend was trend 315 in the contractor's preliminary report.)

Odor Control (313). Improvements in odor control by feedlot managers will enhance our current environment. A gradual increase in the number of feedlots employing waste odor control will continue until 2010, when a substantial (important) number of feedlots will employ these practices.

Increased Feed Efficiency and Alternative Ration Compositions (318). Considered one of the five most important environmentally related trends in feedlot production, this trend's evaluation is complicated by its having both beneficially significant and adversely significant effects.

Its beneficial effects are derived from practices which improve or maintain high grain-to-feed rations. Feed efficiency reduces the feedlot industry's demand for feed grains and, consequently, decreases its waste materials. Feed efficiency for ruminant animals is extensively sought by a significant proportion of these feedlots. It was believed, however, that in the aggregate, feedlots with non-ruminant animals can improve their feed efficiency from a current moderate level of significance by 2010.

The ration composition of feedlots will probably result in an adverse environmental trend. If high roughage rations are used, and it is believed that their use will increase by 2010, longer feeding periods will result. Consequently, as each animal requires more feed, its waste materials will increase too since longer feeding periods will also be required, feedlot space will increase. If high concentrate rations are used in 2010, the increased grain demand due to increased cattle numbers will add pressure in increased cropland production. It was generally believed that high concentrate rations would not be used by a larger proportion of the feedlots in 2010 than in 1976, but the number of feedlots using a high roughage ration will increase. (This trend combined, for ease of discussion, preliminary report trends 302 and 305.)

[1/] Temporary storage in the context of panel discussion implied close covered or contained storage, not solid wastes remaining where deposited.

Geographic Concentration (309). This particular trend received a moderate level of importance for the environment, relative to other feedlot production trends. All classes of feedlot livestock, because of regional production concentrations, already have a relatively high level of concentration. Too, since adequate land will be available in 2010 and current legal statutes for waste management practices will presumably be fully implemented, this trend will not adversely affect the environment. No change in geographic distribution for the major proportion of feedlot livestock was foreseen.

Increasing Pesticide Use (316). A trend towards increasing pesticide use is expected over the next 35 years. Although pesticide use by feedlots would probably double by 2010, no adverse environmental effect is expected. The application of insecticides to and around livestock has been regulated by the USDA and the Federal Food and Drug Administration for several years; consequently, adequate pesticide management should exist in 2010. In addition, the use of pesticides will increase the feed efficiency of livestock and, subsequently, reduce feed demands and waste disposal requirements.

Improved Animal Breeding (301). Improved animal breeding should enhance the environment in 2010. Artificial insemination and cross breeding will nearly double over the next 35 years and will, in turn, increase feedlot efficiency. Two of the basic assumptions behind this conclusion are that considerable gains in estrus control will occur, and artificial insemination will increase in popularity.

Dust and Pest Controls (314). A minor improvement in the 2010 environment is expected to result as the number of feedlots using available controls increase slightly.

Veterinary Services (307). This trend is the tenth most important environmentally related feedlot trend. Prenatal immunization and the use of consulting veterinary services were not considered to have anything more than very minor significance in the future. Vaccines and antibiotics will be of major significance today and in the future. By itself, this subtrend ranked nearly equal to the subtrends of the most important environmental feedlot trend. The beneficial effect of the decrease in death loss and in diseased feedlot animals was evaluated relatively high by the feedlot panel members.

C. Background Summary

The following descriptions and definitions of trends and management practices (subtrends) in feedlot production were provided to the workshop participants as background for the workshop evaluation. In some cases, the panel members chose to re-group selected subtrends or add/delete subtrends as noted. As such, this summary is quasi-independent of the workshop results as presented in Parts A and B, above. However, this summary provides appropriate background base data, definitions, and descriptions of the trends and practices assessed in this portion of the total study.

1. Overview and Base Data

Livestock production has a substantial financial and regional impact on the agricultural sector. Between 1971 and 1973, livestock products provided over half of the cash receipts to farmers, and two-thirds of these came from the sale of red meat animals. Many of these received grain or concentrates in a feedlot prior to being marketed. The geographic concentration of livestock production was shown in Exhibits VIII-4 to VIII-8.

The feedlot industry was defined to be consistent with the intentions of the Environmental Protection Agency. Any livestock operation which has a "concentrated confined animal and poultry growing operation for meat, milk or egg production, a stabling in pens or houses wherein the animals or poultry are fed at the place of confinement and crop or forage growth or production is not sustained in the area of confinement" is considered part of the feedlot industry.

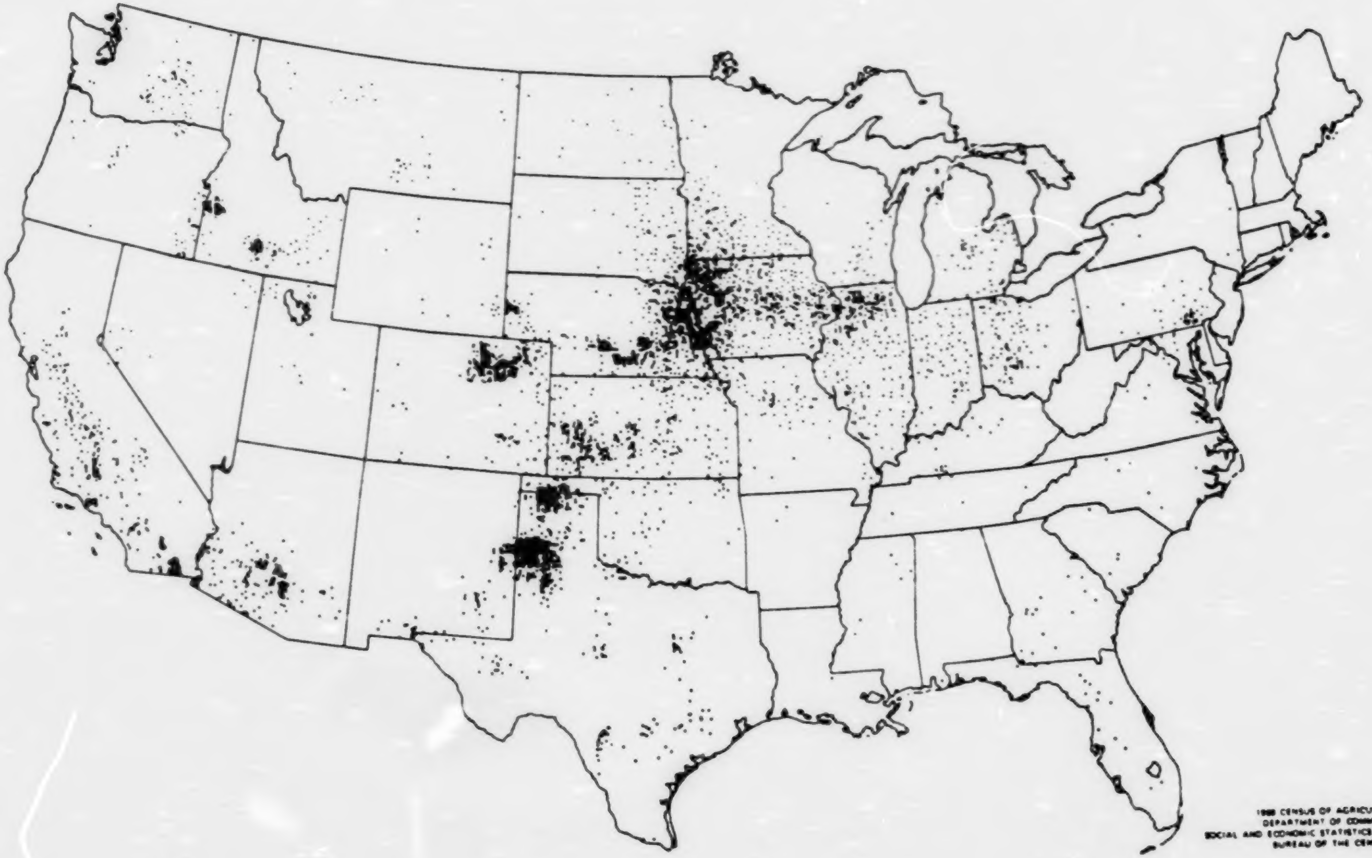
The feedlot industry is very diverse. It is geographically dispersed; it is composed of several classes of livestock produced in a variety of facilities; it utilizes facilities which vary from merely fenced pasture land to totally confined housing units. The economic base and the ownership structure account for many of the differences found in the Feedlot Industry.

Beef Feedlots. Beef feedlots exist in almost every state of the United States and are predominate in the Midwest and West. Feedlot growth is occurring in the Southeast. Feedlots vary in size, in facilities and in economic importance.

The major type of beef feedlots is classified as farmer-feeders with less than 1,000 head capacities. Approximately 98 percent of all feedlots produced fewer than 1,000 head, but they marketed only 35 percent of the fed cattle in 1974. Nearly three-fourths of all feedlots produced fewer than 100 head of fed beef.

Beef feedlots range in size from just a few head to thousands of feeders. There has been a general trend toward larger and larger feedlots, and each year the number of smaller feedlot categories have decreased while the production from larger feedlots has steadily increased. There has also been a regional shift in beef feedlot production which has accompanied this growth in feedlot size. As feed grains become readily available in the South and West, many large feedlots are constructed to utilize the new feed source at its production site.

Exhibit VIII-4. Cattle fattened on grain and sold for slaughter. Each dot represents 5,000 head.



1969 CENSUS OF AGRICULTURE
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Exhibit VIII-5. Milk cows. Each dot represents 1,000 milk cows.

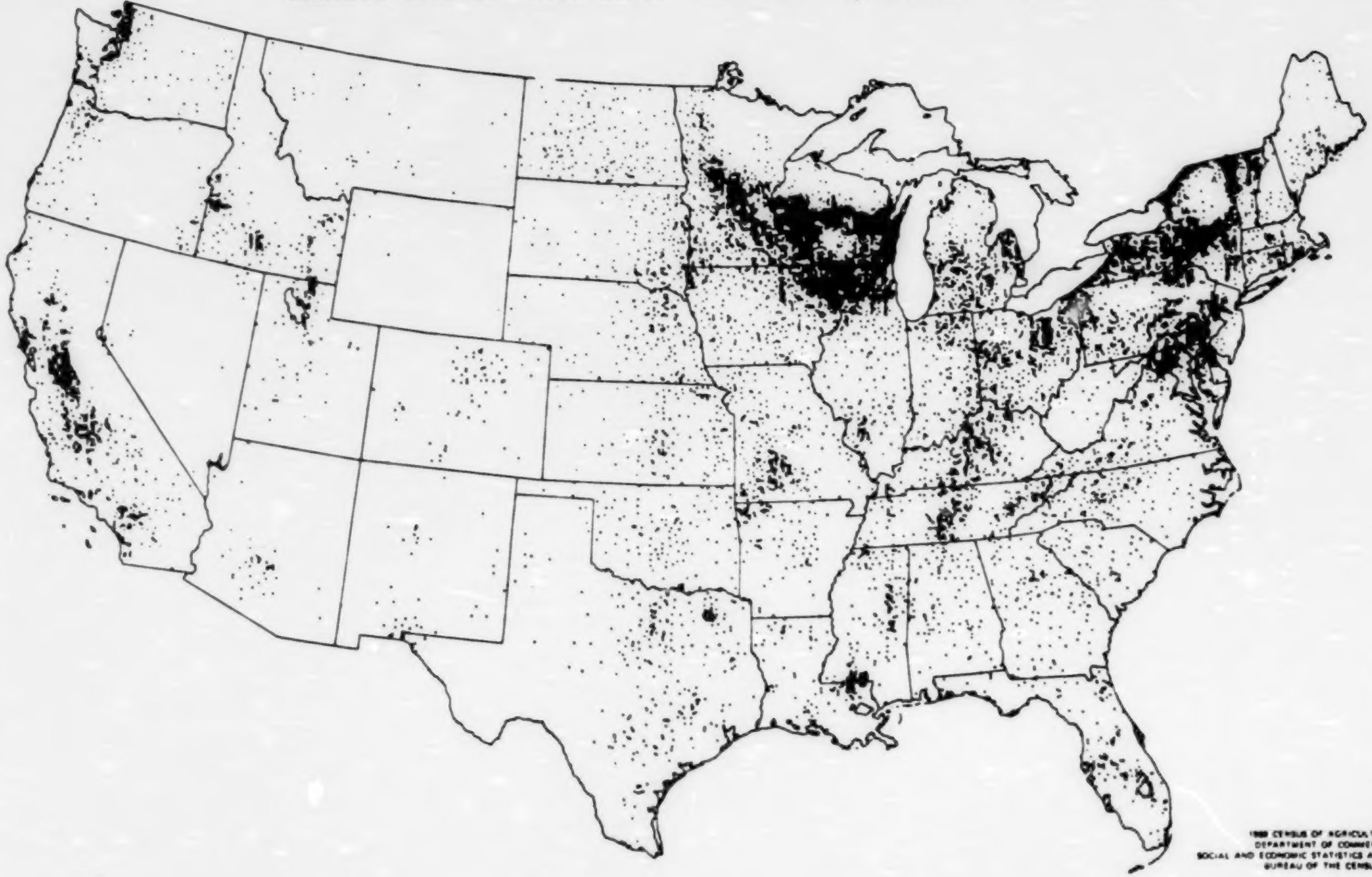

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Exhibit VIII-6. Hogs and pigs. Each dot represents 10,000 hogs.

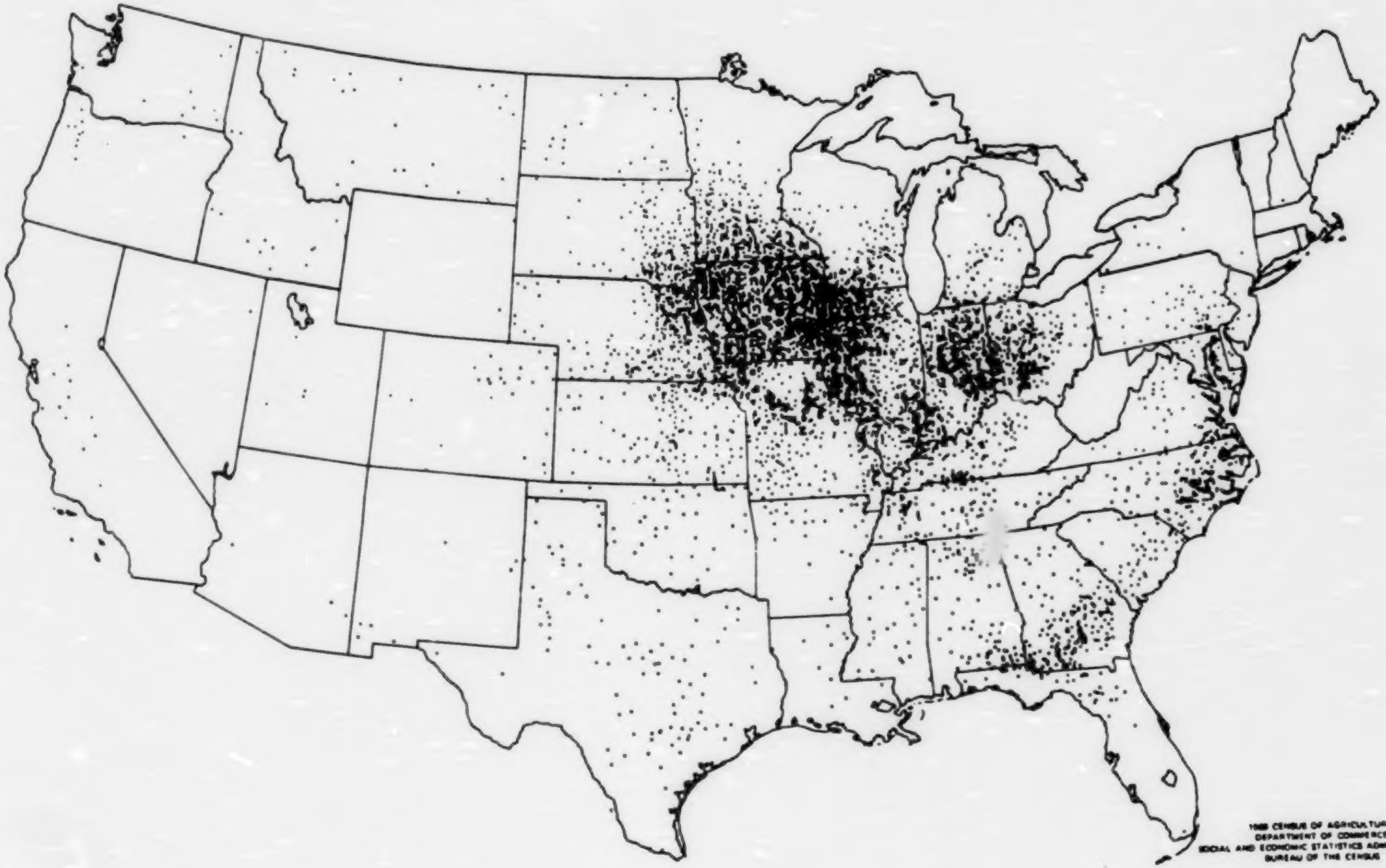

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Exhibit VIII-7. Broilers and other meat-type chickens. Each dot represents 500,000 chickens.

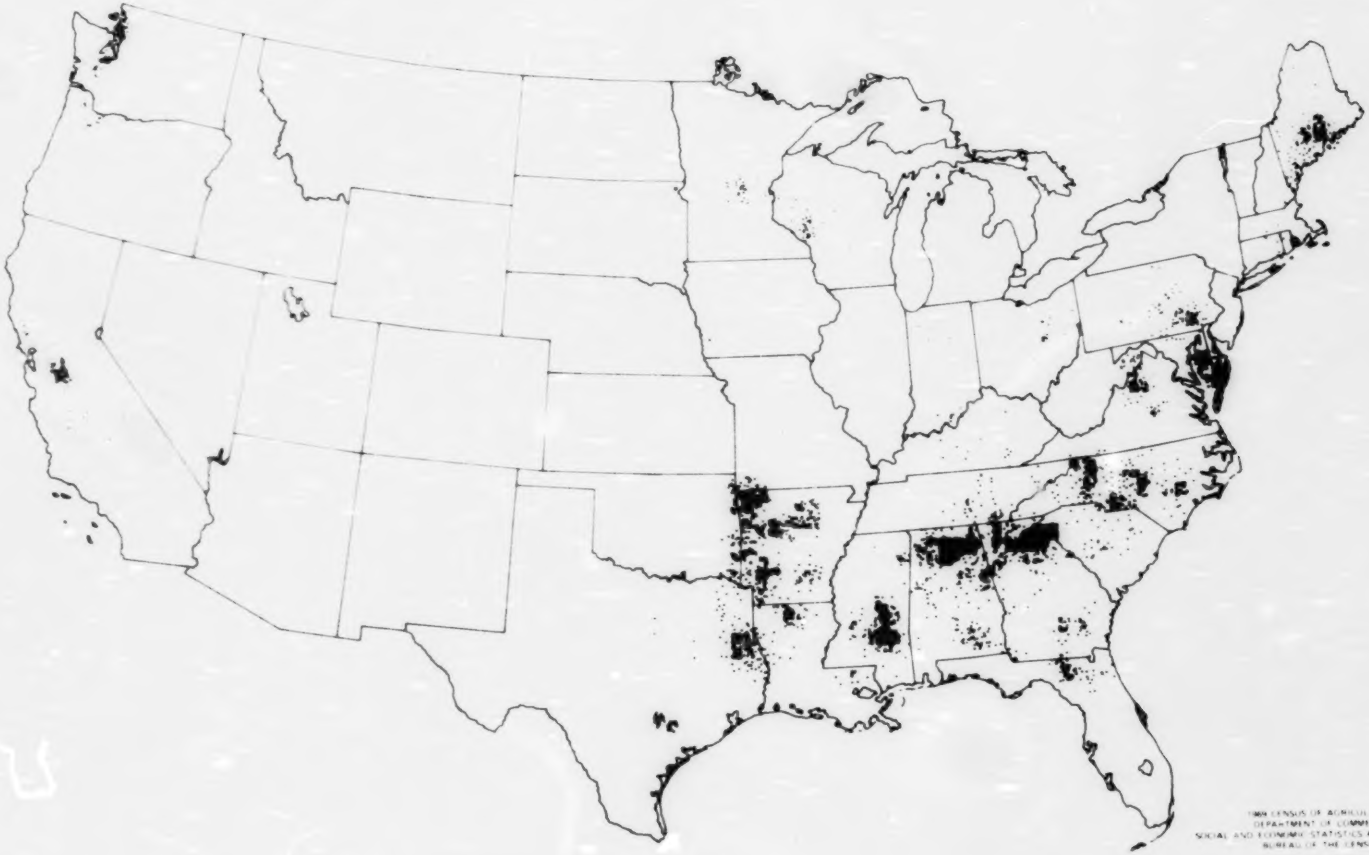

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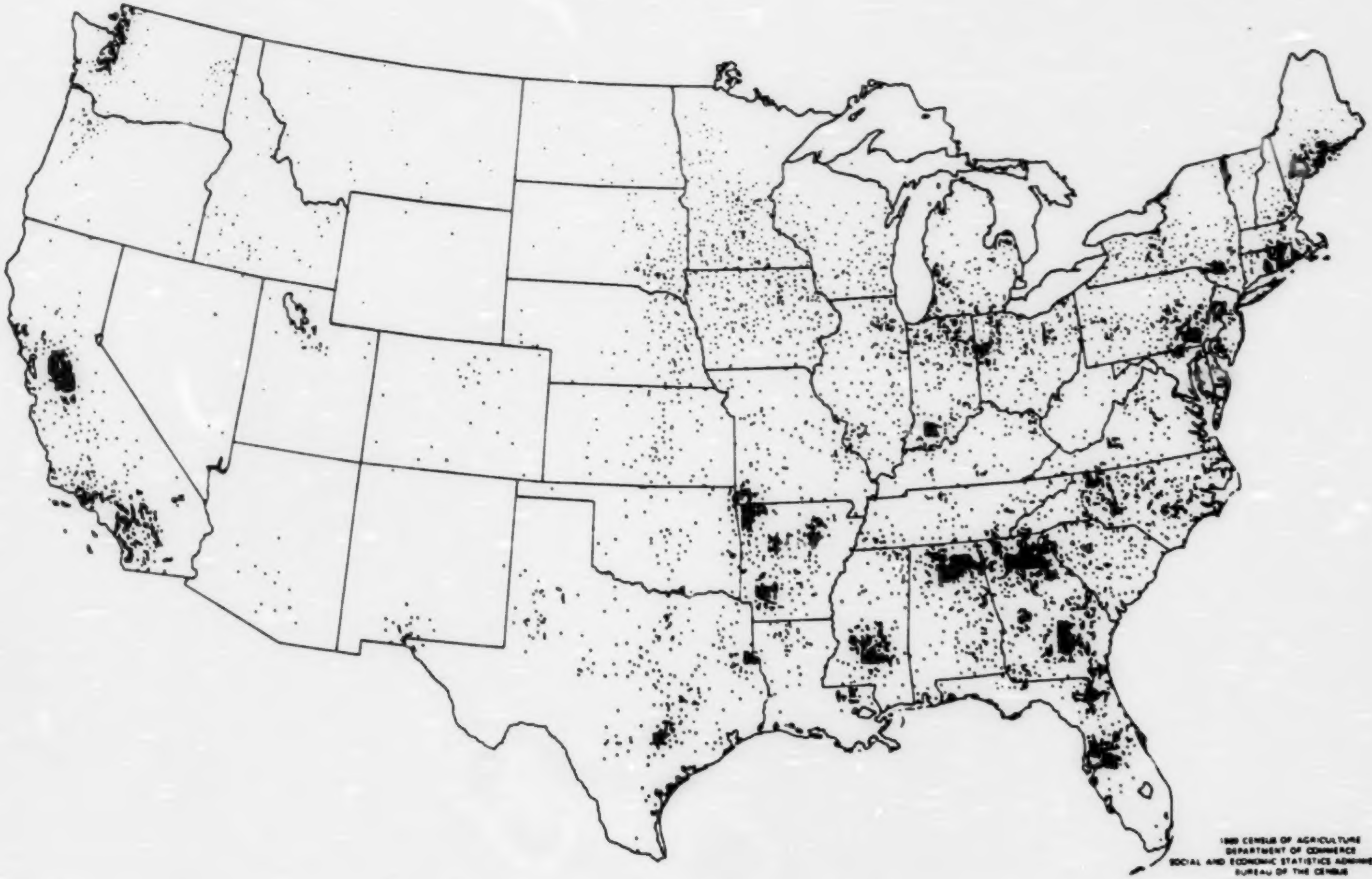
Exhibit VIII-8. Chickens 3 months old or older. Each dot represents 50,000 chickens.



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Many of the new and larger feedlots have adopted the traditional Western feedlot facility design--open feedlots with unpaved surfaces and little or no shelter. The major facility change has been the addition of feed processing equipment. In the eastern half of the United States, beef feedlots have partial housing facilities with mostly unpaved feedlot surfaces. Only two percent of the Eastern feedlots are totally confined facilities.

Swine Feedlots. Hog production is concentrated in the North Central and Southeastern states. The Corn Belt-Lake States have generally produced nearly two-thirds of the total U.S. hog production with Iowa and Illinois alone producing one-third of the U.S. hog production. Often cattle feeding and hog production will occur on the same farm.

Many hog producers are farmer-feeders. Seventy-five percent of all hog producers in the 15 major hog producing states sell fewer than 200 hogs per year. This industry has long been noted for its rapid change of production levels as many small producers with other sources of agricultural income react to hog and feed grain prices. Commonly,hog feeders enter and exit hog feedlot activities more rapidly than do other livestock feeders.

Housing facilities for hog production vary considerably. Nearly half of the farms selling hogs in the 15 major hog producing states use open lots with partially paved or unpaved lots. One-third of the farms use pasture lots, and nearly 13 percent use paved lots. About eight percent use totally confined facilities. The incidence of total confinement facilities increases as the quantity of hogs sold increases. Nearly half of the producers with lots in excess of 1,500 head capacities use totally confined facilities, but fewer than five percent of the hog feedlots under a 100 head capacity use total confinement.

Dairy Feedlots. Dairies are heavily concentrated in the Southeast, the Northeast and California. Most dairy farms will produce a major part of their feed requirements. This usually involves production of a high proportion or all of their pasture and silage requirements and most of their feed grain and hay needs. The degree of production of these feedstuff does vary regionally within the United States. California has been the major exception where large dry lot producers purchase nearly all of their feed and replacement livestock.

The number of dairy feedlots has been declining rapidly. Between 1964 and 1973, the number of dairy feedlots decreased 70 percent. Small dairy farms (30 or fewer milk cows), however, have remained viable and constitute over half of the dairy producers. Only seven percent of the dairy farms were estimated to have 100 cows or more.

All phases of milk production technology have substantially changed over the past few decades, including milking methods and milk handling. Milking machines have replaced hand milking. Bulk milk handling and storage facilities have been widely adopted. The milking facilities have also changed and are classified under three general groups:

- Stall barn with milk room - partially or totally covered facilities
- Free stall barn with milking center - partially or totally covered facilities
- Cow yard with milking center - open lot system.

Partially housed dairy facilities are predominant across all regions of the United States.

Poultry Feedlots. Confined turkeys, ducks, and broilers are considered parts of the poultry feedlot industry. The turkey industry, a highly concentrated industry has relatively few growers, and these are located in limited geographic areas. Turkey production is widely scattered throughout the United States, but there is a concentration of turkey producers in Minnesota, California, North Carolina, and Missouri. Duck production is largely held in the hands of proprietorships and close held family corporations which specialize in duck production. In 1973, there were only 65 production locations for ducks. Broiler production occurs within highly integrated production systems. Most broiler production occurs in the Southeast, East, and California in large confined facilities.

Turkey. All turkeys are started in brooder houses for the first eight weeks of production. The turkeys are then moved to a feeding operation. First, and still the dominant type of operation, is to feed them on fenced pasture land with portable feeders and waterers. The feeding area is moved about the pasture, for the intense concentration of birds near the feeding and watering area generally tramples the grass into barren land.

Duck. Ducks are raised in confined areas until they reach a slaughter weight between five and seven pounds, normally about seven weeks after hatching. Generally seasonal, duck production primarily occurs between March and December. Production activity is often supplemented by the care and maintenance of the brood flock which is usually kept for 12 to 18 months prior to their disposal. Those producers with totally confined housing facilities operate on a year around basis.

About half of the 65 duck feedlots produce between 15,000 and 55,000 ducks per annum, while one-fourth of the duck feedlots are below and one-fourth are above this production range. Generally, the number of producers have tended to decline in the under 15,000 head capacity size group. Total production has been relatively constant since 1962 with production ranging between 9 million and 11 million birds annually.

There are three major types of duck production facilities: wet lots, dry lots, and total confinement. Wet lots allow the ducks to have access to swimming water. Dry lots provide only drinking water for the ducks. Confined facilities utilize a litter over a solid surface and flushing troughs. It was estimated that nearly four-fifths of the duck feedlots are wet lots and about one-fifth are totally confined facilities.

Broiler. The concentration and efficiency of the broiler industry have increased consistently since the depression as the industry has changed from small, widely scattered production units to a large, concentrated industry. Over four-fifths of the broiler production is concentrated in ten states. In addition, 95 percent of the production is either grown under contract or vertically integrated into the entire feeding, processing, and marketing structure of large firms.

Broilers are usually raised in confined facilities using a floor litter system. In about eight weeks time, the broilers are slaughtered as they approach a weight of four pounds.

Nearly five percent of the broiler chicken population is breeder stock kept in totally confined facilities with nesting material, litter covered floors, and slatted or wire covered perches built over pits.

Sheep Feedlots. Sheep feedlots are primarily (80 percent) located in the Western region of the United States and about one-fifth of the sheep feedlots are in the Midwestern Corn Belt States and New York. In the Western region, nearly two-thirds of the feedlots have the capacity to feed between 1,000 and 5,000 head; of the remaining forty percent of the feedlots, about half are below and half are above this 1-5 thousand feedlot size group. Open feedlots are the predominate housing facility.

2. Trends and Environmental Implications */

The feedlot industry encompasses a wide variety of livestock which are geographically dispersed. Consequently the environmental implications are expected to differ among geographic regions. The major aspect common to this very diverse industry is that livestock production will increase substantially by 2010. The management practices which prevail in the future will ultimately determine the environmental impacts of this increased production.

Trends. The general agricultural trend between 1972-74 and 2010 is one of increasing production. The projected farm output index is expected to increase from 110 to 166. Within the livestock sector, production is expected to increase for all classes of livestock except sheep. The output projections for each livestock class is shown in Exhibit VIII-9. below.

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*/ Though not of substantive concern affecting trend rankings and practice assessments arrived at in this study, major trend categories discussed in these base data were in some cases regrouped to facilitate workshop panel discussion. These changes are as follows:

Base Data Categories	became	Revised Categories
315		317
302, 305		318
306, 311, 312		319

Exhibit VIII-9. Livestock production projections

Commodity	Million lbs. Produced 1972-74	Percentage Change from 1972-74 1985	2010
Beef and Veal	22,669	+ 32	+ 75
Pork	13,384	+ 18	+ 49
Chickens	9,028	+ 33	+ 79
Milk	1,169	+ 4	+ 9
Lamb and Mutton	509	- 62	- 60

The manner in which the feedlot industry increases its production will have an important affect on the environment. Without prejudging the positive or negative affect of this projection for increased production, the overall intent is to identify current or future feedlot trends which may be used to achieve the projected production goals.

The major feedlot practices which were expected to have some environmental implication were first initially identified by using a systems approach to feedlot production which is illustrated in Exhibit VIII-10. Aggregate groupings were identified according to science and technological developments, which were: animal science, agricultural engineering, veterinary science, and economics. Trends within these aggregate groupings were identified and are shown in Exhibit VIII-11 and subsequent descriptions are included in Exhibit VIII-12.

The overall number of feedlots are expected to be reduced by at least 50 percent by 2010. This decrease in feedlots and increase in production (i.e. increased size concentrated) is shown in Exhibit VIII-13.

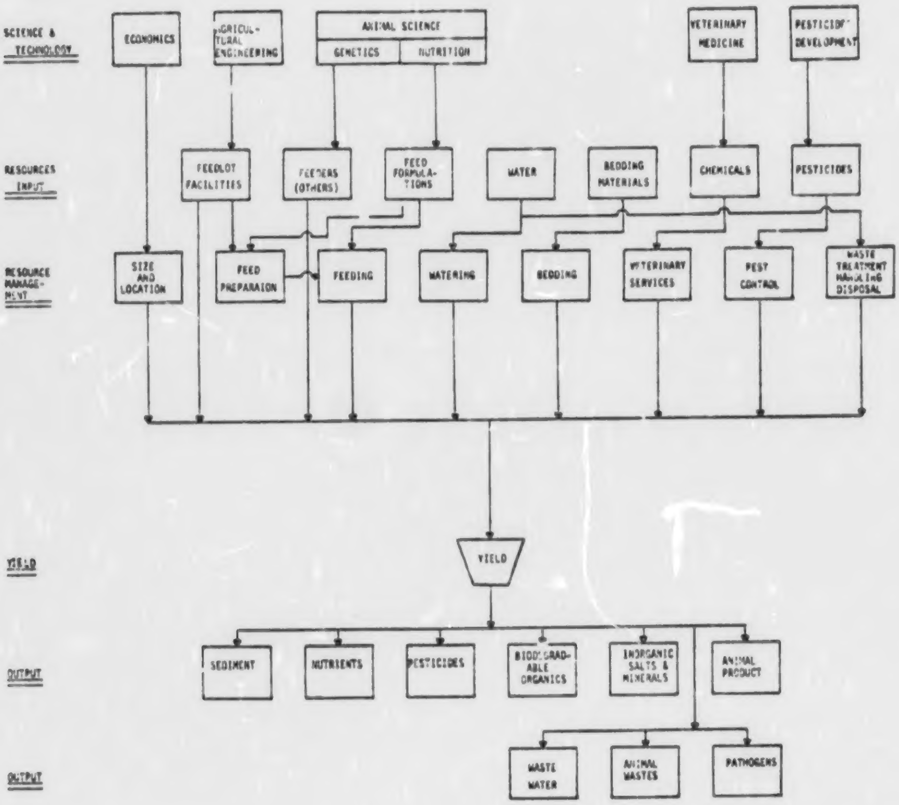
Environmental Implications. The feedlot industry trends which have been identified and described are expected to impact on the environment by either affecting the total quantity of wastes or the concentration of inputs and/or residual factors.

(a) Animal Science Trends. Five specific trends from the Animal Science research were identified: animal breeding, feed efficiency, birth controls, bedding material, and ration formulation.

Improved animal breeding (301) provides the potential to increase productivity per animal. Artificial insemination, cross breeding, and breed selection can impact the environment in two respects: the number of animals required to produce a given output level should decrease and the associated fecal matter should decrease.

Improved feeding efficiency (302) has several possible implications. Feed efficiency, *per se*, will reduce feed consumption, thus reducing the crop-

Exhibit VIII-10. Livestock production system (feedlots)


SCIENCE & TECHNOLOGY
ECONOMICS
AGRICULTURAL ENGINEERING
ANIMAL SCIENCE
GENETICS
NUTRITION
VETERINARY MEDICINE
PESTICIDE DEVELOPMENT
RESOURCES INPUT
FEEDLOT FACILITIES
FEEDERS (OTHERS)
FEED FORMULATIONS
WATER
BEDDING MATERIALS
CHEMICALS
PESTICIDES
RESOURCE MANAGEMENT
SIZE AND LOCATION
FEED PREPARAION
FEEDING
WATERING
BEDDING
VETERINARY SERVICES
PEST CONTROL
WASTE TREATMENT HANDLING DISPOSAL
YIELD
YIELD
OUTPUT
SEDIMENT
NUTRIENTS
PESTICIDES
BIODEGRADABLE ORGANICS
INORGANIC SALTS & MINERALS
ANIMAL PRODUCT
OUTPUT
WASTE WATER
ANIMAL WASTES
PATHOGENS

land production demands and livestock fecal production. Increased use of high cellulose feeds due to processing or chemical treatments will also reduce the grain consumption demands of livestock but it will increase the quantity of livestock wastes. The use of non-conventional feeds by non-ruminants would reduce grain consumption and possibly reduce aggregate livestock wastes for disposal to croplands.

The use of implants is known to increase feed efficiency but it is also suspected to be hazardous to human health.

Improved birth control (303) could drastically reduce the livestock brood herd requirements as much as fifty percent. This has several environmental implications. To achieve brood herd reductions, the brood herds may have to leave the traditional dispersed pasture or range setting and shift to concentrated feedlots to obtain the necessary birth control. Although feed consumption would be reduced, it may mean an increased concentration of animals.

Exhibit VIII-11. Environmentally-related trends in agriculture: Feedlot Production

ANIMAL SCIENCE TRENDS

301. IMPROVED ANIMAL BREEDING
    a. Artificial insemination
    b. Cross breeding
    c. Breed selection

302. IMPROVED FEEDING EFFICIENCY [*]
    a. Ruminants: non-protein nitrogen, rumen fermentation, chemical treatment of forage and crop residue, lipids, processed grains and by-products,
    b. Non-Ruminants: fish protein, single cell protein, leaf protein,
    c. Chemicals: DES, Zeranul, Synonex appetite stimulants

303. IMPROVED BIRTH CONTROL
    a. Hormone implants
    b. Estrus control
    c. Multiple births

304. ALTERNATIVE BEDDING MATERIAL
    (straw)
    (sawdust)
    (other)

305. ALTERNATIVE RATION FORMULATION [*]
    a. High roughage ration
    b. High concentrate ration
    c. Other

AGRICULTURAL ENGINEERING

306. ALTERNATIVE FACILITY DESIGN [*]
    a. Open lot
    b. Dry lot
    c. Total confinement

VETERINARY SCIENCE TRENDS

307. VETERINARY SERVICES
    a. Prenatal immunization
    b. Vaccines and antibiotics
    c. Consulting veterinary services

Exhibit VIII-11 (continued)

ECONOMIC TRENDS

308. INCREASED SIZE OF FEEDLOTS
    a. Beef
    b. Dairy
    c. Swine
    d. Sheep
    e. Poultry

309. INCREASED GEOGRAPHIC CONCENTRATION OF FEEDLOTS
    a. Beef
    b. Dairy
    c. Swine
    d. Sheep
    e. Poultry

310. INCREASED SPECIALIZATION, MECHANIZATION AND USE OF MULTIPLE MAN UNITS
    a. Vertical integration
    b. Single enterprise firms

WASTE MANAGEMENT TRENDS

311. FEEDLOT RUNOFF CONTROL [*]
    a. Retention ponds
    b. Diversion terraces
    c. Settling basins

312. LIQUID WASTE CONTROL [*]
    a. Lagoons
    b. Oxidation ditch

313. ODOR CONTROL
    a. Feedlot animals
    b. Waste management

314. DUST AND PEST CONTROL
    a. Feedlot
    b. Feed preparation

315. SOLID DISPOSAL [*]
    a. Daily
    b. Temporary storage
    c. On site or farm
    d. Off site or off farm

PESTICIDE DEVELOPMENT TRENDS

316. INCREASING PESTICIDE USE (chlordane, aldrin, etc.)

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[*] Trend changes were made by the evaluation workshop as noted in Subsection C-2: Trends and Environmental Implications.

Exhibit VIII-12. Description of environmentally-related trends and developments: Feedlot Production

ANIMAL SCIENCE TRENDS

301. IMPROVED ANIMAL BREEDING
   a. Artificial insemination: Use of stored semen for increasing the number of progeny from genetically superior males

   b. Cross breeding: Mating different breeds of livestock to achieve desired breed characteristics and hy-bred vigor in the offspring

   c. Breed selection: Developing the desired characteristics of particular livestock breeds

302. IMPROVED FEEDING EFFICIENCY[*/]
   a. Ruminants: The addition of chemicals to feedstuffs will enhance the nutritive value obtained from roughage and other high fiber content feed

   b. Non-ruminants: Capable of utilizing non-conventional feedstuffs and animal wastes --reduce grain demands

   c. Chemicals: The implanting or feeding of chemicals which enhance the consumption or feed conversion capabilities of livestock - increased feed efficiency is near 11 percent

303. IMPROVED BIRTH CONTROL
   a. Hormone implants: Affect litter size -(as much as 84 percent in swine)

   b. Estrus control: Greatly improves the efficiency of artificial insemination by the use of chemicals (Prostaglandin F2)

   c. Multiple births: Increased number of offspring by drug treatments

304. ALTERNATIVE BEDDING MATERIAL - Dry matter added to the feedlot to absorb moisture and odor

305. ALTERNATIVE RATION COMPOSITION [*/]
   a. High roughage ration: Feedstuffs have a high cellulose content which causes a lower rate of gain and longer feeding period

   b. High concentrate ration: Feedstuffs having relatively high energy content per unit and higher rates of gain

Exhibit VIII-12 (continued)

AGRICULTURAL ENGINEERING TRENDS

306. ALTERNATIVE FACILITY DESIGN */
   a. Open lot: Feedlots with no roofed shelters and no paved surfaces except limited areas in front of feed bunks

   b. Dry lot: Feedlots with roofed structures and paved or unpaved surfaces

   c. Total confinement: Feedlots with either cold-covered shelters enclosed or at least three sides or warm-enclosed shelters

VETERINARY SCIENCE TRENDS

307. VETERINARY SERVICES
   a. Prenatal immunization: Pre-birth innoculations to produce disease-free livestock at the time of birth

   b. Vaccines and antibiotics: Innoculations to reduce death losses and maintain or improve feedlot gains

   c. Consulting veterinary services: Routine use of veterinary skills to improve herd health - only 30 percent of initial disease occurrence is treated by veterinarians

ECONOMIC TRENDS

308. INCREASED SIZE OF FEEDLOTS - Among most classes of livestock production is increasing and the number of feedlots are decreasing - exception is sheep (See Exhibit IV-C 10)

309. INCREASED GEOGRAPHIC CONCENTRATION OF FEEDLOTS - The location of specific feedlot types have become more concentrated in particular regions - see Exhibits IV-C-1 to 5

310. INCREASED SPECIALIZATION. MECHANIZATION AND USE OF MULTIPLE MAN UNITS - An increase in the concentration of man power and machinery has resulted from the growth in large feedlots

WASTE MANAGEMENT TRENDS

311. FEEDLOT RUNOFF CONTROL */
   a. Retention ponds: A facility designed to temporarily store feedlot runoff and waste water

   b. Diversion terraces: An earthen embankment used to divert surface water away from the feedlot surface

   c. Settling basins: A shallow pit between the feedlot surface and the retention pond to allow heavier solids to settle out of the runoff prior to reaching the retention pond

Exhibit VIII-12 (continued)

312. LIQUID WASTE CONTROL [*]
   a. Lagoon: An excavated pond for biological treatment of runoff, waste water and manure
   b. Oxidation ditch: An aerated open cnannel which receives animal wastes which are reduced by aerobic bacteria-nearly odorless operation which uses a relatively high quantitiy of energy and water

313. ODOR CONTROL
   a. Feedlot animals: Odors are emitted from the fecal matter deposited on the feedlot surface - effective controls have not been established

   b. Waste management: Improper operation of retention ponds allows odor causing anaerobic bacteria to grow

314. DUST AND PEST CONTROL
   a. Feedlot: Flies are a common problem around many feedlots

   b. Feed preparation: Rodents and dust generally occur around feedlots with feed processing equipment

315. SOLIDS DISPOSAL [*]
   a. Daily: Daily disposal of solid wastes (a common practice for dairy feedlots)

   b. Temporary storage: Temporary storage of wastes (a new trend among dairy producers to reduce spreading of wastes on frozen ground)

   c. On site or farm: On site or on farm disposal of solid wastes is traditional practice of farmer-feeder operations

   d. Off site or off farm: Off site or off farm disposal of solid wastes (increasing as large feedlots become land intensive)

316. INCREASING PESTICIDE USE - pesticides has been used for control of lice, mites, flies, grubs, ticks, screw worms, and mange.

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[*] Trend changes were made by the evaluation workshop as noted in Subsection C-2: Trends and Environmental Implications.

Exhibit VIII-13. Overall trends in feedlot concentrations

Livestock/Year	Estimated No. of Feedlots 1973	1977	1983
Beef	185,000	142,500	92,500
Swine	425,000	370,000	287,000
Sheep	10,000	(-)	(-)
Dairy	329,000	N.A.	148,200
Turkey	4,000	3,000	2,500
Duck	65	(-)	(-)
Total	953,065	≤844,500	≤540,300

Livestock	Units	Estimated Production 1973	1977	1983
Beef	mil. head	31.6	38.3	41.6
Swine	mil. head	82.0	96.2	106.4
Sheep	mil. head	2.8	N.A.	N.A.
Dairy	bil. lbs.	115.0	N.A.	109.0
Turkey	mil. birds	132.0	150.0	163.0
Duck	mil. birds	10.99	relatively constant	

Alternative bedding material (304) can reduce the moisture content and odor associated with fecal matter. Bedding added to the feedlot surface, however, increases the quantity of solids to be disposed of from the feedlot.

Alternative ration composition (305) allows feedlot producers to adjust to economic conditions. Increased roughage use will tend to increase the length of the feeding period and the quantity of feedlot wastes. High grain or concentrate rations tend to increase the demands on cropland production.

(b) Agricultural Engineering Trends. Agricultural engineers have dealt with many aspects of the feedlot industry. Facility designs were solely identified as having important environmental implications. Other contributions by these engineers were included in other trends but were not specifically identified as engineering contributions.

Alternative facility designs (306) allow for the reduction in feedlot runoff as exposed surface areas are reduced by various housing types. Research has also indicated that total confinement systems lower death losses (10-20%) and increase feed efficiency about 10 percent.

(c) Veterinary Science. Several contributions to the livestock industry can be attributed to the improved health of livestock.

Veterinary services (307) tend to reduce the incidence of livestock death and disease. Productivity is generally increased. No correlation with human health hazards due to chemical treatments has been found.

(d) Economic Trends. The financial incentive to produce feedlot livestock has resulted in gains to the owners as well as society. These benefits, however, have been partially offset by the increased incidence of environmental degradation.

Increased size of feedlots (308) is expected. The environmental implication is uncertain since the size factor and the geographic location are both important variables. Generally, increasing the concentration of any environmentally sensitive factor will put additional demands on the assimilative capacity of the environment.

Increased geographic concentration of feedlots (309) will increase the quantity of feedlot wastes which must be assimilated into the local environment.

Increased specialization, mechanization and multiple man units (310) will add additional pressure on the environment. Odor, dust and noise pollution will probably be affected most drastically.

(e) Waste Management Trends. These trends have basically reduced the potential of environmental degradation. Further efforts are needed to encourage the proper operation of facilities and the continued adoption of waste management technology.

Feedlot runoff control (311) affects the quantity of wastes which are carried by surface water. Feedlot runoff is generally high in B.O.D. and organic matter. Increased control will require additional cropland disposal sites which may affect cropland production.

Liquid waste controls (312) are designed to decompose animal wastes. These practices reduce the quantity of solids which must be disposed on to cropland.

Odor controls (313) are essential non-existent for feedlots. As feedlots increase in size and population centers expand, continued conflicts are expected. Proper waste management can affect the odors resulting from feedlot runoff systems.

Dust and pest controls (314) affect the air and health environment of surrounding population centers.

Solids disposal (315) affect the quality of cropland runoff. Daily spreading encourages solid disposals on wet and frozen ground; such activity permits potential surface water runoff degradation. Temporary storage can reduce surface water runoff but it can also reduce the environmental aesthetics and may increase odor potential.

Increasing pesticide use (316) has occurred with new chemical developments. Approximately 5-6 percent of the pesticide expenditures in 1964 were applied to livestock and poultry. The application of insecticides to and around livestock is regulated by the USDA and the Federal Food and Drug Administration to limit the health hazard of contaminated meat and milk.

SECTION IX

ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 4 - RANGE AND PASTURE MANAGEMENT

The Range and Pasture Management Panel evaluated and ranked the maor environmentally related trends in this subsector of agriculture as summarized in Exhibit IX-1, and as described briefly in Exhibit IX-2. Also, the panel's ratings of each subtrends extensiveness of use and intensiveness of environmental effects, which were developed as a means for establishing the overall environmental ratings, are as shown in Exhibit IX-3.

The trends assessed by Panel 4 were those associated with livestock management practices on the nation's 1,202 million acres of rangeland (ranges in native or natural grasses, plus forested ranges) and the 101 million acres of land in pastures.

The Range and Pasture Management Panel was comprised of four members and was chaired by Glen Flucher. The panelists represented a balance both in specialties and geographical areas of interest.

Name	Representing	Specialty	Geographical Area
Glen D. Fulcher	Bureau of Land Mgt.	Range Management	Western
John Launchbaugh	Kansas State Univ.	Range Management	Great Plains
J. M. Scholl	University of Wis.	Forage Crops	Northeast
John Studeman	Agriculture Research Service	Pastures, Animal Science	Southeast

A. Major Trend Rankings and Practice Assessments

The trends which Panel 4 considered adequate as a basis for its assessment were those contained in the Contractor's preliminary report. A number of modifications were made by the panel: these include the addition of several subtrends and a combination of a number of trends into single trends. As previously discussed in Section IV, "Workshop Procedures", the procedure used by the panel in assessing trends involved: an analysis of the extensiveness

(E) and intensiveness (I) of each of the subtrends; a determination of the overall significance rating (R) of these subtrends (R = EXI); a determination of a composite rating when all trends were considered; and finally, a ranking of the trends based on these adjusted ratings (AR). In the initial assessment by the panel, the individual subtrends were analyzed separately in pasture and range management because of the significant differences between the two; however, in the final ranking, the subtrends were combined, and a single rating was determined for each trend. Exhibit IX-1 shows the ranking of the trends as determined by the panel.

B. Environmental Implications of Major Trends and Practices

Each of the major range and pasture management trends, as determined by Panel 4, are summarized below. Background descriptions and definitions of these trends, which served as the basis for the workshop's evaluations, are included for reference in Part C: "Background Summary," as needed.

Grazing Practices (406). Panel 4 determined grazing practices to be the most significant trend, environmentally, both because of the large

Exhibit IX-1. Ranking of environmentally-related trends, 1976-2010: Range and Pasture Management

Rank	Trend number[1]	Trend[2]	Adjusted rating
1	406	Grazing practices	8
2	405	Stocking rates	7
3	401	Range and pasture renovation	6
4	416	Using increased resources	5
5	417	Range and pasture improvements	5
6	409	Increasing nutrition from vegetation	4
7	408	Genetic improvements	4
8	403	Inter-seeding improved or preferred forage varieties	2
9	412	Insect and disease control	2
10	414	Poisonous plant control	2
11	410	Increasing use of irrigation	1
12	413	Small animal control	1

[1] The trend number reflects those numbers used in the Phase I-Interim Report.

[2] The panel ranked only trends 1 through 7. Trends 8-12 were ranked by DPRA based on the extensiveness and intensiveness ratings made by the panel.

Exhibit IX-2. Description of major environmentally-related trends, 1976-2010: Range and Pasture Management

Panel Rank	Trend Number and Title	Adjusted Rating for 2010	Comments and Modifications
1	(406) Grazing Practices	8	Grazing practices include continuous grazing systems and specialized systems, which allow for rotations during certain seasons. A trend toward specialized systems will generally improve soil and vegetation more rapidly than continuous grazing.
2	(405) Stocking Rates	7	Proper numbers of animals are allowed to graze for the type of vegetation and management system used. Proper rates will enhance forage quality and productivity and reduce soil erosion.
3	(401) Range and Pasture Renovation	6	Renovation practices include mechanical and chemical methods and prescribed burning. Environmental quality will be improved by the establishment of grass cover and stabilization of soil.
4	(416) Using Increased Resources	5	Range and pasture will use increased amounts of fertilizers and pesticides, and will develop new range and pasture. Quality, quantity, and productivity of range and pasture will be affected beneficially by increased resource use.
5	(417) Range and Pasture Improvements	5	The trend toward water improvement, with the construction of ponds, catchment basins, and drainage structures, and such structural developments as fire barriers and fencing, will aid in grazing management and improve forage quality.
6	(409) Increasing Nutrition from Vegetation	4	Nutritional levels of vegetation will result from the use of chemical additives and forage supplements. Quality and digestibility of forage will improve from use of this trend.
7	(408) Genetic Improvements	4	Forage quality will be improved by the genetic developments of forage with increased stress tolerance, digestibility, and production.

Exhibit IX-3. Environmental ratings of top ten trends and associated practices: Range and Pasture Management

Rank	Trend Number	Trend and Subtrends	Extensiveness						Intensiveness	
			Range			Pasture			Range	Pasture
			(1976)	(1985)	(2010)	(1976)	(1985)	(2010)		
1	(406)	Grazing Practices								
		a. Continuous	3	3	2	2	2	2	-2	+1
		b. Specialized grazing systems (rotations)	1	1	2	2	3	3	+2	+2
		c. Complementary forage seedings	1.	2	3	1	2	3	+2	+2
2	(405)	Stocking Rates (controlled grazing)	2	3	4	2	3	4	+3	+3
3	(401)	Range and Pasture Renovation								
		a. Mechanical	1	1	1	1	3	3	+2	+2
		b. Chemical	2	2	3	1	2	2	+1	+2
		c. Prescribed burning	1	2	2	0	0	0	+2	N.A.
4	(416)	Using Increased Resources								
		a. Using chemicals, pesticides, & fertilizers	1	1	[illegible]	2	3	4	+1	+2
		b. Developing new range & pasture lands	1	1	2	1	1	2	+2	+2
5	(417)	Range and Pasture Improvements								
		a. Ponds & catchment basins	2	2	3	1	2	2	+2	+1
		b. Drainage	0	0	0	1	1	1	0	+1
		c. Wells, pipe lines & troughs	1	2	3	1	1	1	+1	+1
		d. Range fire barriers	1	1	2	0	0	0	-1	N.A.
		e. Cross & containment fencing	1	2	3	2	3	3	+1	+1
		f. Sediment & erosion control structures	1	2	2	1	1	2	+1	+1
		g. Water and salt dispersal	2	2	3	1	2	3	+1	+1
6	(409)	Increasing Nutrition from Vegetation								
		a. Increasing rumen efficiency	1	3	4	1	3	3	+1	+1
		b. Increasing retention of forage quality	1	1	2	1	2	3	+1	+1
		c. Increasing vitamin & protein supplements	2	3	3	1	2	2	+1	+1
		d. Improved nutrient balance	1	2	3	2	3	4	+1	+1
7	(408)	Genetic Development								
		a. Increasing forage quality & quantity	1	1	2	2	2	3	+1	+1
		b. Increasing stress tolerance	1	1	2	1	2	3	+1	+1
8	(403)	Inter-Seeding Improved or Preferred Forage Varieties								
		a. Legumes	1	1	1	1	2	3	+1	+1
		b. Preferred grasses	1	1	1	1	2	2	+1	+1
9	(412)	Insect and Disease Control	<1	<1	<1	2	2	3	+1	+1
10	(414)	Poisonous (Noxious) Plant Control	1	1	1	2	2	2	+1	+1

land area involved in pasture and range and because of the environmental implications of the various types of practices. There was considerable controversy within the panel concerning the actual trends in practices that could be expected between now and 2010 and in the environmental implications of continuous grazing. One point of view held was that continuous grazing was extremely detrimental to the environment and, because of this, other types of systems will necessarily have to be implemented. The opposite point of view was that continuous and properly controlled grazing was beneficial to the quality of forage and would be the only system economically feasible in the future. Regardless of the specific trends and effects (beneficial vs. adverse) under the two points of view, the panel agreed that trends in grazing practices constitute the major concern in range and pasture management.

The basic subtrends in grazing practices involve continuous and specialized systems. Complimentary seeding practices can be incorporated into either of the two systems. According to the panel, continuous grazing is relatively extensive on ranges, while rotation grazing is minor. By 2010, the extensiveness of the two will be at somewhat the same levels with continuous grazing declining and specialized grazing increasing. In pasture operations, the extensiveness of continuous grazing is expected to remain essentially the same through 2010; however, with new pasture development, the specialized systems are expected to increase to a moderate level by that year. The extensiveness of complimentary seeding is expected to increase significantly on both range and pasture. As discussed above, conflicting points of view were expressed in the panel in connection with the environmental impact of continuous range grazing. Most of the panelists gave an intensiveness rating of minus 2 to this practice to reflect the potentially adverse effects of continuous grazing. The ratings of other subtrends in range and pasture reflected generally beneficial effects.

Stocking Rates (405). This trend, directed towards controlled (or proper) stocking rates, was ranked second. The panel's discussion of this trend centered on what the trend toward proper rates actually meant and where or how the trend should be classified. In most of the regions, a trend towards controlled rates suggests that the change will be from overgrazing to proper grazing. However, in the Southeast, the trend reflects a change from undergrazing to proper grazing, for there, the problem is one of undergrazing which results in the growth of less desirable grasses and forbs. Two of the panelists felt that the stocking rate was a component of the grazing system and, consequently, should be combined with grazing systems. However, the trend was kept separate and was given a rating in environmental significance close to that of grazing practices.

The trend toward controlled (or proper) stocking rates was considered essentially the same in both range and pasture management. Currently, the extensiveness of proper grazing is considered relatively minor; however, by 2010 it is expected to increase significantly to an important level. This trend is expected to have a significantly beneficial effect on the environment as reflected in the intensiveness rating given by the panel.

Range and Pasture Renovation (401). This trend, ranked third, was considered to include nonstructural improvements such as revegetation and brush control and seedbed preparation in pastures. The panel concluded that renovation was a more significant factor in pasture operations than it was in range management.

As indicated in Exhibit IX-3, the panel expects the trend in mechanical renovation to increase significantly by 2010 in pasture operation while it is expected to remain at a minor level in range operations. On the other hand, the panel rated the extensiveness of chemical renovation as relatively more important in range management than in pasture operations. Chemical application on both range and pasture is expected to increase slightly by 2010. The environmental effects associated with these types of renovation were judged by the panel to have overall beneficial effect even though, in most cases, short-term detrimental effects may occur, primarily from soil compaction and disturbance. Prescribed range burning is occurring now only at minor levels, but it is expected to increase somewhat by 2010. Again the effects are beneficial in the long run. Prescribed burning is not expected for pasture renovation.

Using Increased Resources (416). The panel ranked this trend fourth, although its adjusted rating of vie was the same as fifth ranked, Range and Pasture Improvements (417). It is a composite of Trends 411 and 415 as described in Part C, below. Increased use of fertilizer, pesticides, and chemicals on land and as well as the development of new pasture and range lands are covered by this trend. The panel concluded that the development of new pastures and ranges is expected to occur primarily in the Southeast with foest land here being converted to range and pasture. Use of these increased resources was adjudged by the panel to have overall beneficial effects upon the environment even in light of potentially adverse short-term effects. Chemicals and pesticides are currently being used only to a minor degree on ranges; no significant changes in this use are anticipated for 2010. This use is considerably greater on pasture and is expected to increase to even higher levels by 2010. In developing new range and pasture, only a slight increase is expected by 2010; the most extensive development is anticipated to occur in the Southwest.

Range and Pasture Improvements (417). This trend, ranked five, is a consolidation of trends 402, 404 and 407 contained in Part C, below, including an increasing use of structural improvements in water development, fencing, erosion control, and fire barriers.

The extensiveness of the use of these improvements was considered currently minor for both range and pasture but are expected to increase slightly by 2010. All of these trends in the developments were given beneficial ratings in intensiveness except in the case of fire barriers. The panel felt that the use of fire barriers would impede the use of controlled fires on ranges and, consequently, it would result in some adverse effects. As shown in Exhibit IX-3, the remaining subtrends in range and pasture management were expected to have beneficial effects; however, as reflected in the intensiveness ratings, these effects were expected to be relatively minor.

Other trends. The panel ranked two additional trends, Increasing Nutrition from Vegetation (409) and Genetic Improvements (408) at an adjusted rating of four. The remaining trends contained in the Phase I-Interim Report were considered by the panel to be relatively minor and were not ranked. They are listed in Exhibit IX-3 with extensiveness and intensiveness ratings as discussed below.

The rankings outlined above were arrived at by the panel based on its evaluation of the extensiveness and intensiveness ratings. Ratings for the subtrends are shown in Exhibit IX-3 for both range and pasture management.

C. Background Summary

The following descriptions and definitions of trends and practices (subtrends) related to range and pasture management were provided to the workshop participants as background for the workshop evaluation. In some cases, the panel members chose to re-group selected subtrends or add/delete subtrends as noted. As such, this summary is quasi-independent of the workshop results in Parts A and B, above. However, it provides appropriate background base data, definitions and descriptions of the trends and practices assessed in this portion of the total study.

1. Overview and Base Data

Ranges, which include both rangeland (lands in native and natural grass) and forest land, comprised 1202 million acres in 1970 in the conterminous 48 states (USDA, 72). The total acreage of rangeland and the percent of it that is grazed for each of the ecogroups is listed below.

U.S. Rangeland in 1970

Ecogroup	Total Ranges	Ranges Grazed Acres	Ranges Grazed Percent
	(million acres)		
Western Range	418.6	360.8	86
Western Forest	160.6	97.2	61
Great Plains	228.9	217.1	95
Eastern Forest	393.4	159.8	41
ALL RANGES	1,201.5	834.9	70

Alaska's ranges comprise over 300 million acres; however, largely federally owned, they were grazed very little. Hawaii has less than 3 million acres and most is under private ownership.

Over 50 percent of the ranges in the Western area are under federal ownership. On the other hand, in the Great Plains, just over 10 percent is federally owned and, in the Eastern Forest, less than 10 percent.

The level and types of range management vary significantly among the ecogroups. The most extensive use of range occurs in the Great Plains with over 90 percent of the range being grazed. The least extensive use of range occurs in the Eastern Forest with only about 40 percent of the rangeland being used for grazing purposes.

The 1970 total acreage in improved pastures is listed below (USDA, 72). Pastures differ from ranges in two respects: (1) pasture forages are generally non-native and (2) pastures generally receive annual improvment such as fertilization.

Improved Pastures by Geographic Region

Geographic Region	Pastures (million acres)	Percent
Western	8.9	9
Plains	24.0	24
Northeast	39.9	39
Southeast	28.3	28
Total	101.1	100

Source: The Nation's Range Resources (USDA, 72).

The potential sources of pollution from ranges and pastures include sediment, pesticides, fertilizer, and animal and plant wastes. These pollutants can be transported to surface waters by direct runoff, sediment movement, or percolation.

Sediment is not only the most significant pollutant in terms of volume, but it is also the chief carrier of plant nutrients, pesticides, organic and inorganic matter, pathogens, and other water pollutants. While sediment from ranges and pastures contribute to water pollution, soil erosion (movement of the sediment from the land) represents the greatest environmental damage to the land itself. Soil erosion presents more significant problems on ranges than it does on pastures, because of the improvements that pastures receive. The range acre rates for hydralogic output by ecogroup are listed below.

Ecogroup	Water Yield Acre Feed	Quality Water Acre Feed Per	Storm Runoff[1/] Inches Per Acre Per Year	Sediment Tons Per Acre Per Year
Western Range	0.24	0.23	0.32	2.74
Western Forest	1.10	1.05	0.44	0.52
Great Plains	0.80	0.03	0.72	1.12
Eastern Forest	1.24	1.11	1.37	0.43
Weighted Average	0.65	0.59	0.76	1.38

1/ Runoff expected from a 2-year 2-day storm.

Source: The Nation's Range Resources (USDA, 72).

The annual loss of sediment from ranges averages 1.38 tons per acre. The loss in the Western Range is over twice as much as for any of the other groups even though the water yield and storm runoff is significantly less. The Eastern Forest which has the greatest water yield and storm runoff has the least sediment loss. In recent estimates made by the Environmental Protection Agency, the total annual sediment loss from both ranges and pastures is about 1.2 billion tons. Cropland which comprises total acreage of less than a fourth of that of ranges and pastures accounts for 1.8 billion tons.

Two types of nutrients are recognized as presenting possible and differing pollution problems on ranges and pastures: nitrogen and phosphorus. Sources for these nutrients are fertilizer and animal wastes. Nitrogen, more soluble in water, can pollute both surface and ground water through direct runoff or percolation; phosphorus relatively insoluble attaches itself to sediment and moves with it to surface water. While fertilizers and animal wastes are possible pollutants from ranges and pastures, their actual contribution to the nutrient loading of waterways is relatively minor. Recent estimates by the Environmental Protection Agency show that nitrogen loading of water from ranges and pastures, is several tons per day less than cropland loading. On a weighted average basis, this would indicate that similar loading from cropland is close to six times as great as that from ranges and pastures. By far the greatest amount of the nutrients entering the water are from background concentrations, i.e., natural sources--soil and organic matter). The actual overall loadings resulting from range and pasture management is not known; however, it is assumed to be relatively insignificant. Many studies have concluded that nutrient loading is most reflective of rainfall amounts than of fertilization ratios.

Most pesticides applied to pastures and ranges are herbicides used for the control of undesirable vegetation. In 1971, a total of 8.3 million pounds of these pesticides was applied to pastures and rangelands (USDA, 72), a total less than 4 percent of that applied to croplands. A number of research studies have concluded that less than 5 percent of the pesticides enters the waterways through runoff.

2. Trends and Environmental Implications [*/]

Management of ranges and pastures involve the utilization of practices which differ considerably among ecogroups. Although the entire management system must be viewed within these ecogroups in order to assess the total impact on the environment, each of the practices can be examined in determining its specific implications.

Trends. The general relationship of these practices within the management systems are illustrated in Exhibit IX-4. Included in the system are the management practices (resource management) resource inputs, technological developments, and system outputs to include the major residuals generated. This system provides the framework in which the trends in range and pasture management have been identified. Those trends to be discussed and analyzed are listed in Exhibit IX-5 and then described in Exhibit IX-6. The trends have been grouped under the following major headings: (1) range and pasture developments, (2) grazing management trends, (3) plant improvements, (4) nutrition improvements, (5) irrigation technology, and (6) fertilizer developments and range pollution trends.

Environmental Implications. In the analysis of trends, the matrix contained in Exhibit IX-7 was developed so that potential interactions between the specific practices and pollutants generated could be examined. These interactions represent changes that would occur in the amounts of pollutants produced on a representative range or pasture managed under practices assumed to be utilized in 1976. The interactions were denoted with pluses (+) and minuses (-), a decreasing effect or beneficial impact was indicated with a +, an increasing effect on pollutants generated was indicated with a -. Based on a review of these interactions, general conclusions were drawn on the trends and environmental implications.

(a) Range and pasture developments. Trends in range and pasture developments included range renovation, water improvements, interseeding improved or preferred grass varieties and structural developments.

Brush control used in renovation (401) (primarily range) can be accomplished by a number of means to include: mechanical, chemicals, or burning. Each of these measures has both short term and long term effects on the environment. In the short term, mechanical

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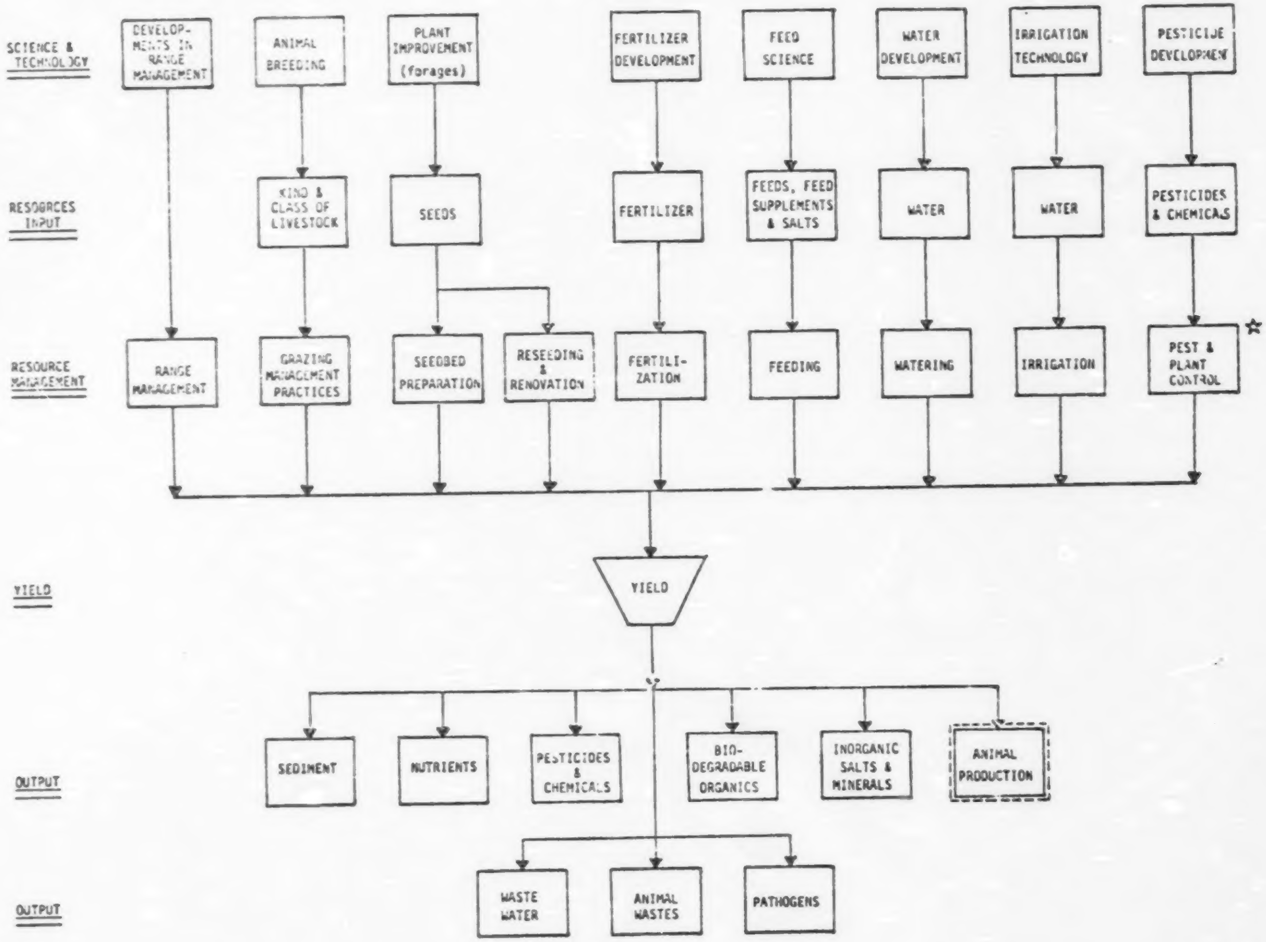
[*/] Though not of substantive concern affecting trend rankings and practice assessments arrived at in this study, major trend categories discussed in these base data were in some cases regrouped to facilitate workshop panel discussions. These changes are as follows:

Base data categories	became	Revised categories
402, 404, 407		417
411 and 415		416

Exhibit IX-4. Range and pasture systems


SCIENCE & TECHNOLOGY
RESOURCES INPUT
RESOURCE MANAGEMENT
YIELD
OUTPUT
OUTPUT
DEVELOPMENTS IN RANGE MANAGEMENT
ANIMAL BREEDING
PLANT IMPROVEMENT (forages)
FERTILIZER DEVELOPMENT
FEED SCIENCE
WATER DEVELOPMENT
IRRIGATION TECHNOLOGY
PESTICIDE DEVELOPMENT
KIND & CLASS OF LIVESTOCK
SEEDS
FERTILIZER
FEEDS, FEED SUPPLEMENTS & SALTS
WATER
WATER
PESTICIDES & CHEMICALS
RANGE MANAGEMENT
GRAZING MANAGEMENT PRACTICES
SEEDBED PREPARATION
RESEEDING & RENOVATION
FERTILIZATION
FEEDING
WATERING
IRRIGATION
PEST & PLANT CONTROL ☆
YIELD
SEDIMENT
NUTRIENTS
PESTICIDES & CHEMICALS
BIO-DEGRADABLE ORGANICS
INORGANIC SALTS & MINERALS
ANIMAL PRODUCTION
WASTE WATER
ANIMAL WASTES
PATHOGENS

☆ OTHER PRACTICES : Herding, Hunting, Fencing, Predator control

Exhibit IX-5. Environmentally-related trends: Range and Pasture

RANGE AND PASTURE DEVELOPMENTS

401. RANGE RENOVATION
    - a. Mechanical
    - b. Chemical
    - c. Prescribed burning

402. WATER IMPROVEMENT: RANGE AND PASTURE [1/]
    - a. Ponds and catchment basins
    - b. Drainage

403. INTER-SEEDING IMPROVED OR PREFERRED GRASS VARIETIES: RANGE AND PASTURE

404. STRUCTURAL DEVELOPMENTS: RANGE AND PASTURE [1/]
    - a. Range fire barriers
    - b. Cross and containment fencing

GRAZING MANAGEMENT TRENDS

405. STOCKING RATES: RANGE AND PASTURE
    - a. Proper use - range
    - b. Proper use - pasture

406. GRAZING PRACTICES: RANGE AND PASTURE
    - a. Continuous
    - b. Deferred Rotation
    - c. Rest Rotation

407. DECREASING LIVESTOCK CONCENTRATION: RANGE AND PASTURE
    - a. Water and salt dispersal
    - b. Cross fencing

PLANT IMPROVEMENTS

408. GENETIC DEVELOPMENT: RANGE AND PASTURE [1/]
    - a. Increasing forage quality and quantity
    - b. Increasing stress tolerance

NUTRITIONAL IMPROVEMENTS

409. INCREASING NUTRITION FROM VEGETATION: RANGE AND PASTURE
    - a. Increasing rumen efficiency - monensin
    - b. Increasing retention of forage quality-chemical treatment
    - c. Increasing vitamin and protein supplements

[1/] Included in Workshop Panel ratings as Trend 117.

Exhibit IX-5 (continued)

IRRIGATION TECHNOLOGY

410. INCREASING USE OF IRRIGATION
    - a. Range irrigation
    - b. Pasture irrigation

FERTILIZER DEVELOPMENTS

411. INCREASING FERTILIZER USE [2/]
    - a. Commercial application to range
    - b. Commercial application to pasture
    - c. Biological nitrogen fixation

RANGE AND PASTURE PROTECTION TRENDS

412. INSECT AND DISEASE CONTROL
    - a. Range (surveillance, chemicals)
    - b. Pasture (surveillance, chemicals)

413. SMALL ANIMAL CONTROL
    - a. Range control (surveillance, chemicals)
    - b. Pasture control (surveillance, chemicals)

414. POISONOUS PLANT CONTROL
    - a. Range control (herbicides, controlled grazing)
    - b. Pasture control (herbicides, controlled grazing)

RESOURCE USE TRENDS

415. USING INCREASED RESOURCES [2/]
    - a. Using chemicals, pesticides and fertilizer on range land
    - b. Using chemicals, pesticides and fertilizers on pasture land
    - c. Developing new range and pasture lands

[2/] Included in Workshop Panel ratings as Trend 116.

Exhibit IX-6. Description of environmentally-related trends and developments in range and pasture

RANGE AND PASTURE DEVELOPMENTS

401. RANGE RENOVATION
    a. Mechanical: cutting and/or uprooting range shrubs by tractors, chains, blades, etc.
    b. Chemicals: herbicide application by aerial or ground equipment to eleminate shrubs and undesirable plants
    c. Prescribed burning: predetermined range areas are intentionally burned to control undesirable shrubs

402. WATER IMPROVEMENTS */
    a. Ponds and catchment basins: water impoundment made by constructing a dam or excavating a pit
    b. Drainage: removing excess surface or ground water

403. INTER-SEEDING IMPROVED OR PREFERRED GRASS VARIETIES:*/ planting seeds among existing grass varieties

404. STRUCTURAL DEVELOPMENTS
    a. Fire barriers: creating a barrier of bare or scoured earth between rangeland and fire hazards such as highway, railroad
    b. Fencing: containment and cross fencing

GRAZING MANAGEMENT TRENDS

405. STOCKING RATES: RANGE AND PASTURE

    a. Proper use range: the proper number of animals are allowed to graze for the type of vegetation and management system used.
    b. Proper use pasture: the proper number of animals are allowed to graze for the type and condition of vegetation and management system used.

406. GRAZING PRACTICES: Range and Pasture
    a. Continuous grazing: vegetation is entirely grazed by stock
    b. Deferred Rotation: alternate use of grazing areas to develop production of desired species of grass
    c. Rest rotation: grazing occurs only during certain seasons and allows a given area to grow without livestock interference

Exhibit IX-6 (continued)

407. DECREASING LIVESTOCK CONCENTRATION */
   a. Pond and salt dispersal: water and salt are strategically located to encourage less intensive grazing at specific sites
   b. Cross fencing: used to restrict movement of livestock towards habitually preferred areas

408. GENETIC DEVELOPMENTS
   a. Increasing forage quality and quantity: genetically developing forage to enhance digestibility, palatability and production
   b. Increasing stress tolerance: genetically developing grass to produce under saline, drought or excessive moisture conditions

NUTRITIONAL IMPROVEMENTS

409. INCREASING FORAGE NUTRITION
   a. Increasing rumen efficiency: chemical additives designed to increase ruminant's capability to absorb forage nutrients (monensin)
   b. Increasing retention of forage quality: chemical treatment for maintaining forage quality
   c. Increasing vitamin and protein supplements: adding vitamins and proteins to supplement the nutritive quality of forage

IRRIGATION TECHNOLOGY

410. INCREASING USE OF IRRIGATION: on ranges and pasture to increase productivity (sprinklers and well developments are increasing in usage)

FERTILIZER DEVELOPMENTS

411. INCREASING FERTILIZER USE */
   a. Range applications: relatively limited quantities are applied since a large share of rangeland is in arid regions
   b. Pasture applications: wide range in fertilizer quantity and composition

RANGE AND PASTURE PROTECTION TRENDS

412. INSECT AND DISEASE CONTROL
   a. Ranges: scouting by visual surveillance, use of pesticides
   b. Pastures: scouting by visual surveillance using pesticides, nematacides, fungicides, bacteriocides

Exhibit IX-6 (continued)

413. SMALL ANIMAL CONTROL
    - a. Ranges
    - b. Pastures

414. POISONOUS PLANT CONTROL
    - a. Range: surveillance controlled grazing, herbicides, burning
    - b. Pasture: surveillance controlled grazing, herbicides, burning

RESOURCE USE TRENDS

415. USING INCREASED RESOURCES [*]
    - a. Chemicals and pesticides on rangeland
    - b. Chemicals, pesticides, and fertilizers on pasturelands
    - c. Developing new range and pasturelands

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[*] See subsection C-2: Trends and Environmental Implications, for changes in trend groupngs by the evaluation workshop.

Exhibit IX-7. Environmentally-related trends: Ranges and Pastures

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
RANGE AND PASTURE DEVELOPMENTS																
401. RANGE RENOVATION	-	0	-	-	0	-	0	0	0	0	-	-	0	0	0	-
a. Mechanical	-	0	-	0	0	-	0	0	0	0	-	-	0	0	0	-
b. Chemical	0	0	0	-	0	-	0	0	0	0	0	0	0	0	0	-
c. Prescribed burning	-	0	-	0	0	-	0	0	0	0	-	-	0	0	0	-
402. WATER IMPROVEMENTS: RANGE & PASTURE	+	0	0	0	+	0	0	0	0	0	+	+	0	0	0	0
a. Ponds & catchment basins	+	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0
b. Drainage	+	0	0	0	+	0	0	0	0	0	+	+	0	0	0	-
403. INTERSEEDING: RANGE & PASTURE	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
404. STRUCTURAL DEVELOPMENTS: RANGE AND PASTURE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
a. Range fire barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Cross and containment fencing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAZING MANAGEMENT TRENDS																
405. STOCKING RATES	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
a. Controlled range grazing	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
b. Controlled pasture grazing	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
406. GRAZING PRACTICES: RANGES & PASTURES	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
a. Continuous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Deferred rotation	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
c. Rest rotation	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-

Exhibit IX-7 (continued)

TRENDS	Potential Contribution to Pollution--Major Pollutants															
	Surface Water						Ground Water			Air		Land				
	Sediment	Nitrogen	Phosphorus	Pesticides	Inorganic salt and minerals	Biodegradable organics	Nitrates	Pesticides	Inorganic salt and minerals	Gases	Particulates	Soil erosion	Salinity	Heavy metals	Pesticide residues	Biodegradable organics
407. DECREASING LIVESTOCK CONCENTRATION: RANGE AND PASTURE	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
a. Pond and salt disposal	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
b. Cross fencing	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
PLANT IMPROVEMENTS: RANGE & PASTURES																
403. GENETIC DEVELOPMENT	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
a. Increasing forage quality	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
b. Increasing stress tolerance	+	0	0	0	0	-	0	0	0	0	+	+	0	0	0	-
NUTRITION IMPROVEMENTS																
409. INCREASING NUTRITION FROM VEGETATION: RANGE AND PASTURE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
a. Increasing rumen efficiency-monensin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Retention of forage quality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c. Increasing vitamin and protein supplement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATED TECHNOLOGY																
410. INCREASING USE OF IRRIGATION	+	0	0	0	0	0	0	0	0	0	+	+	-	0	0	0
a. Range irrigation: sprinkler, wells	+	0	0	0	0	0	0	0	0	0	+	+	-	0	0	0
b. Pasture irrigation: sprinkler, wells	+	0	0	0	0	0	0	0	0	0	+	+	-	0	0	0
FERTILIZER DEVELOPMENTS																
411. INCREASING FERTILIZER USE	+	-	-	0	0	0	0	0	0	0	+	+	0	0	0	0
a. Commercial application: range	+	-	-	0	0	0	0	0	0	0	+	+	0	0	0	0
b. Commercial application: pasture	+	-	-	0	0	0	0	0	0	0	+	+	0	0	0	0
c. Biological nitrogen fixation	+	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0
RANGE AND PASTURE PROTECTION TRENDS																
412. INSECT AND DISEASE CONTROL	0	0	0	-	0	0	0	-	0	0	0	0	0	0	-	0
a. Range	0	0	0	-	0	0	0	-	0	0	0	0	0	0	-	0
b. Pasture	0	0	0	-	0	0	0	-	0	0	0	0	0	0	-	0
413. SMALL ANIMAL CONTROL	0	0	0	-	0	0	0	-	0	0	0	0	0	0	-	0
a. Range control	0	0	0	-	0	0	0	-	0	0	0	0	0	0	-	0
b. Pasture control	0	0	0	-	0	0	0	-	0	0	0	0	0	0	-	0
414. POISONOUS PLANT CONTROL	0	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0
a. Range	0	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0
b. Pasture	0	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0
RESOURCE USE TRENDS																
415. USING INCREASED RESOURCES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

measures such as root plowing, chaining, crushing, and pushing contribute to water pollution by increasing (in many cases) soil erosion. The application of herbicides may present problems under some conditions in pesticide runoff. However, in the long run, these practices enhance the environment by establishing grass cover and stabilizing the soil.

Water improvements (402) include the construction of ponds and catchment basins and drainage. Ponds and catchment basins, used in watering livestock, affect the environment both directly and indirectly. As a method of water conservation, they decrease the erosion potential of the soil. Their major impact on the environment is indirect and involves livestock distribution on the ranges and pastures. Proper location of these developments reduces the concentration of livestock in small areas decreasing the chances of bare spots and sedimentation of nearly streams. Drainage, which is relatively a small trend on ranges, is used to improve the forage and access. Its environmental implications are an improvement in soil stability as well as producing a higher quality forage.

Interseeding improved or preferred grass varieties (403) is used both on pastures and ranges and is used principally for improving the quality of the forage. However, benefits to the environment accrue from an improved soil cover which maintains itself over a longer period of time. Interseeding introduces improved species as well as reestablishing indigious species.

Structural developments (404) include measures designed to aid grazing management and to protect the forage. Important trends are an increasing use of fine barriers on ranges and cross and containment fencing on both ranges and pastures. The benefits to the environment of these developments are primarily indirect and relate to the protection of the forage which in turn promotes soil stability.

(b) Grazing management trends. Grazing management is conducted under two basic systems: continuous and rotation. Significant practices include stocking rates and measures in decrease livestock concentration.

Stocking rates (405) have significant environmental implications both on ranges and pastures. High stocking rates not only affect the condition and productiveness of the forage but also reduces soil stability causing erosion and compaction of the soil. On the other hand, low stocking rates generally enhance forage productivity and reduces soil erosion.

Grazing practice (406), as indicated above, include continuous and rotation grazing. In turn, rotation contains two variations: deferred and rest. Rotation grazing is a more intensive system of management and generally improve soil and vegetation conditions more rapidly than the continuous system.

Decreasing livestock concentration (407) is accomplished by measures such as pond and salt dispersed and fencing. By controlling livestock distribution on ranges and pastures, problems in erosion associated with compaction and bare spots can be reduced.

(c) Plant improvements. Trends in plant improvement are expected to occur both on range and pasture and involve genetic developments.

Genetic development (408) encompasses a wide variety of scientific developments that increase the forage quality and quantity and stress tolerances. These innovations contribute to soil stability primarily by introducing on range and pasture a more effective ground cover.

(d) Nutrition improvements. Increasing nutrition from vegetation (409) is not only beneficial to livestock production but also increase the grazing capacity of range and pasture. This reduces the potential for overgrazing and decreases problems in soil erosion. Specific trends include increasing rumen efficiency, retention of forage quality-chemical treatment, and vitamin and protein supplements.

(e) Irrigation technology. There is a trend in the increasing use of irrigation (410) both on range and pasture. Increasingly areas deficient in water are receiving applications of water by sprinklers and This is increasing the forage quality and grazing capacity with beneficial effects on the environment (primarily soil stability).

(f) Fertilizer developments. Increasing fertilizer use (411) on range and pasture is expected to have both beneficial and adverse effects. Increasing rates may present some problems in water pollution with the possibility of greater runoff. However, a more significant effect relates to the increase in herbage production and quality which will increase the grazing capacities. As discussed above, this will lessen the potential of soil erosion.

(g) Range and pasture protection trends. Range and pasture protection refers to those practices used to control insects, diseases, and small animals which reduce the production of forage.

Insect and disease control (412) includes both chemical and biological treatments; however, the major trends are toward pesticide use. Potential problems exist both on ranges and pastures from pesticide runoff; in addition, destruction of insects may affect primary food chains on the range with adverse effects on wildlife.

Small animal (rodent) control (413) includes both chemical and mechanical measures and is frequently accomplished in conjunction with seeding on ranges. The environmental impact of these controls, as in insect control, primarily relates to damages to wildlife rather than water or land pollution. The destruction of rodents interrupts a primary food chain on the ranges.

Poisonous plant control (414) can involve a number of control measures to include mechanical, chemical, and biological means and by prescribed fire. The control of noxious and poisonous plants pose problems similar to those associated with insect and rodent control. While the threat of water pollution is minor, the potential damages to wildlife are more significant.

(h) Resource use trends (415). The trends discussed above were viewed in light of impacts which were expected to occur from changes in practices as utilized on a hypothetical range and pasture. In many cases, the practices involved changes in the use of resources such as land, pesticides, and fertilizer. Collectively, these practices may be expected to have significant effects on resource use and hence on the environment, although the trends with overriding importance are those of increasing levels of resource inputs associated with the increasing demand for livestock products. The inputs that pose significant environmental implications are fertilizers, pesticides, and land used in range and pasture development. By the year 2010, the use of fertilizers and pesticides is projected to increase substantially. These increases, which constitute the basic forces on the environment, bring into focus the fundamental problems involving water, air, and land pollution. All of the practices and developments previously identified must be viewed in this perspective.

SECTION X

ENVIRONMENTAL IMPLICATIONS OF AGRICULTURAL AND SILVICULTURAL TRENDS: PANEL 5 - SILVICULTURE AND HARVEST MANAGEMENT

Panel 5 assessed and ranked the major environmentally related trends in silviculture and harvest management as summarized in Exhibit X-1. Brief definitions and descriptions of these trends are presented in Exhibit X-2; and these trends are discussed further in Part C: "Background Summary," which was provided to the workshop participants prior to the workshop as a basis for the workshop evaluation. Over 490 million acres of commercial timber owned by the federal government, industry and private individuals are represented by the Panel's assessment area.

The Silviculture and Harvest Management Panel assessed each trend and its environmental implications at both the regional and national levels. Exhibit X-3, prepared directly by Panel 5, illustrates, the expected regional as well as the national environmental implications of selected trends between 1976 and 2010. Also, each subtrend was rated according to its extensiveness of use and intensiveness of environmental effect for 1976 and 2010 as summarized in Exhibit X-4. These ratings were then used to establish overall trend ratings by the panel.

The Silviculture and Harvest Management Panel was comprised of five experts from the government, education and industry. Panel members with their speciality and geographic area are listed below. Noel Larson was panel chairman.

Name	Representing	Specialty	Geographic Area
Noel Larson	U.S. Forest Service Washington, D. C.	Hydrology	California
George Dissmeyer	U.S. Forest Service Atlanta, Georgia	Hydrology	South and Southeast
Warren Harper	Weyerhaeuser Co. Tacoma, Washington	Hydrology and Harvest Mgt.	Pacific Coast
Stanley Ursic	U.S. Forest Service Oxford, Mississippi	Hydrology	South
David Wooldridge	University of Wasnington	Forest Watershed Management	Pacific Coast

Exhibit X-1. Ranking of environmentally-related trends, 1976-2010: Silviculture and Harvest Management

Panel Rank	Trend Number 1/	Trend	Adjusted Rating
1	(502)	Access to timber resource	4
2	(505)	Site preparation	4
3	(503)	Log extraction	3
4	(504)	Utilization	2
5	(510)	Fire control	2
6	(508)	Growth enhancement	2
7	(507)	Stand conversion	2
8	(509)	Pest control	2
9	(501)	Cutting system	1
10	(506)	Stand establishment	1

1/ The trend number reflects those numbers used in the Phase I--Interim Report.

A. Major Trend Rankings and Practices Assessments

The "Background Summary" contains the silviculture trends that Panel 5 assessed and ranked. Each panel was free to delete any of these trends, and new trends, or make other necessary changes to effectively arrive at trends representing their area. The Silviculture panel did not add or delete major trends, but did make minor changes at the subtrend level.

The Silviculture Panel felt there were many regional differences within silviculture trends and their implications. Management of a Douglas Fir forest in Oregon is completely different from the management of the South's pine forest, and both are very different from that for the hardwood forests of the North; consequently, trends and their implications were assessed on a regional basis by forest types. These regions and forest types are the West, mixed conifer; the East, hardwood; the East, softwood. Finally a national assessment was made by adding regional implication assessments. Exhibit X-3 presents this implication assessment of trends by regions and nationally for 1976 and 2010. The implications of silviculture trends were given a 100 rating, nationally, for 1976.

Exhibt X-2. Description of major environmentally-related trends, 1976-2010: Silviculture and Harvest Management

Panel Rank	Trend Number and Title	Adjusted Rating for 2010	Comments and Modifications
1	(502) Access to Timber Resource	4	Trends to provide access roads to timber resources will be for construction of permanent and temporary roads and for reconstruction of permanent and temporary roads and for reconstruction and maintenance of existing roads. Emphasis will be on temporary roads and road maintenance and reconstruction as harvesting management intensifies.
2	(505) Site Preparation	4	Fertilizer and chemical treatments, burning prescriptions, mechanical preparations and log extraction methods will be used to create more favorable planting sites. Forest regeneration will be enhanced by these practices.
3	(503) Log Extraction	3	Harvest management will use plans and specifications for optimum log extraction systems. Production machinery will be used in log extractions with trends toward newer, more efficient machines and application methods.
4	(504) Utilization	2	Logging practices will develop to use smaller logs, than currently being extracted, to use tree species now considered non-commercial, and to use waste material left in forest after extraction.
5	(510) Fire Control	2	Improved fire prevention and detection methods, use of fire to reduce disastrous fire potential, and wildlife suppression will be used by silviculture in 2010 for fire control.
6	(508) Growth Enhancement	2	Forest growth rates and production levels will increase with thinning practices, elimination of noncommercial tree species, and with use of fertilization, fire, and chemical application practices.
7	(507) Stand Conversion	2	Management programs will eliminate undesirable tree species and plant desirable commercial tree species in their place.
8	(509) Pest Control	2	Forest pest control practices will include use of pesticides, use of biological agents (attractants, repellants, pheromones), and use of mechanical methods to eliminate infested material.
9	(501) Cutting System	1	Trends in forest cutting systems are clear cutting, seedtree cutting, group cutting, selection cutting, and shelterwood and diameter cuttings. Each management system will use the cutting method that best meets its needs.
10	(506) Stand Establishment	1	Forest regenerations will be enhanced, by determining the best method of regeneration, best species to be planted, and best type of planting material, method, and spacing for that species.

Exhibit X-3. Environmental implications of all silviculture trends, regional and national, 1976-2010 1/

Panel Rank	Trend Number	Trend	Western Region-1976	Eastern Regions-1976			National-1976	Western Region-2010	Eastern Regions-2010			National-2010
			Mixed Conifer	Hardwood	Softwood			Mixed Conifer	Hardwood	Softwood		
1	(502)	Access to Timber Resources	28	3	4	=	35	20	3	2	=	25
2	(505)	Site Preparation	3	1	26	=	30	4	3	18	=	25
3	(503)	Log Extraction	4	4	2	=	10	4	4	2	=	10
4	(504)	Utilization	1	1	2	=	4	1	2	3	=	6
5	(510)	Fire Control	3	1	2	=	6	3	1	2	=	6
6	(508)	Growth Enhancement	1	1	2	=	4	2	2	3	=	7
7	(507)	Stand Conversion	1	--	6	=	7	1	--	5	=	6
8	(509)	Pest Control	Trace	Trace	Trace	=	1	Trace	Trace	Trace	=	1
9	(501)	Cutting System	1	1	--	=	2	1	1	--	=	2
10	(506)	Stand establishment	Trace	Trace	Trace	=	1	Trace	Trace	Trace	=	1
		TOTALS	42+	12+	44+	=	100	36+	16+	35+	=	89

1/ The environmental implications resulting from all silviculture trends was given a national rating of 100 in 1976. Each trend contributed a certain percent to this 100 implication value as shown in the National column for 1976. Additionally, there are regional differences for the use and implementation of each trend, so that the national implication rating for each trend was divided into three regional implication values reflecting the impact of the trend in that region (i.e. in 1976, Timber Access (502) was resonpsible for 35 percent of all the environmental implications from silviculture, with 28 percent resulting from Western region timber access practices, 3 percent from Eastern hardwood region, and 4 percent from the Eastern softwood region).

These trends were also assessed by regions and nationallv for 2010. The national implication value in 2010 was 89 reflecting an 11 percent decrease in environmental implications from silviculture.

Exhibit X-4. Environmental rating of top ten trends and associated practices: Silviculture and Harvest Management

Rank	Trend Number	Trend and Subtrends	Extensiveness Rating I			Intensiveness Rating (I)		Rating (E x I)		Change in Rating (ΔR)1/
			1976	1985	2010	1976	2010	1976	2010	
1	(502)	Access to Timber Resources								
		a. Road construction-permanent roads	3	2	1	-3	-1	-9	-1	+8
		b. Road maintenance	2	3	4	-3	-1	-6	-4	+2
		c. Road construction-project roads	3	4	3	-3	-1	-9	-3	+6
		d. Reconstruction	1	2	3	-3	-1	-3	-3	0
2	(505)	Site Preparations								
		a. Log extraction method	3	2	2	-1	0	-3	0	+3
		b. Mechanical preparation	3	4	3	-3	-1	-9	-3	+6
		c. Burning prescription	3	3	3	-2	-1	-6	-3	+3
		d. Chemical treatment	1	2	2	-1	0	-1	0	+1
		e. Fertilizer treatment	1	2	2	-1	0	-1	0	+1
		f. Soil moisture control	2	2	1	-1	0	-2	0	+2
3	(503)	Log Extraction								
		a. Harvest unit layout-intensity of effort	3	4	4	-2	0	-6	0	+6
		b. Equipment use and development	3	4	5	-2	-1	-6	-5	+1
4	(504)	Utilization								
		a. Extraction residue recovery	3	3	1	-2	-1	-6	-1	+5
		b. Minimum size and quality extension	3	4	5	-1	-2	-3	-10	-7
		c. Species use enlargement	2	3	4	-1	-2	-2	-8	-6
5	(510)	Fire Control								
		a. Prevention method improvements	3	4	4	-1	0	-3	0	+3
		b. Detection method improvements	3	3	4	-1	0	-3	0	+3
		c. Fire use method improvements	2	3	4	-1	0	-2	0	+2
		d. Wildlife control improvements	4	4	4	-1	0	-4	0	+4
6	(508)	Growth Enhancement								
		a. Stocking control by thinning	2	3	4	0	+1	0	+4	+4
		b. Undesirable tree species elimination	2	3	3	0	+1	0	+3	+3
		c. Fertilization	1	2	2	-1	0	-1	0	+1
		d. Fire	1	2	2	-1	0	-1	0	+1
		e. Irrigations (including waste disposal)	1	1	2	-1	+1	-1	+2	+3
7	(507)	Stand Conversion								
		a. Species replacement	2	3	2	0	+1	0	+2	+2
8	(509)	Pest Control								
		a. Chemical agents	2	3	3	-1	0	-2	0	+2
		b. Mechanical treatment	1	1	1	NA		--	--	
		c. Biological agents	1	1	2	NA		--	--	
9	(501)	Cutting System								
		a. Clear cutting	4	3	5	-2	-1	-8	-5	+3
		b. Seed-tree cutting	1	1	1	-2	-1	-2	-1	+1
		c. Group cutting	1	2	2	-2	-1	-2	-2	0
		d. Selection cutting	2	3	3	-1	0	-2	0	+2
		e. Shelterwood	1	2	1	-1	0	-1	0	+1
		f. Diameter cut	2	2	1	-1	0	-2	0	+2
10	(506)	Stand Establishment								
		a. Planning species selection	2	3	4	-1	0	-2	0	+2
		b. Planting material selection and/or development	2	3	4	-1	0	-2	0	+2
		c. Planting mechanization	1	2	2	-2	-1	-2	-2	0
		d. Stocking control by spacing	2	3	4	NA				
		e. Natural regeneration	2	2	1	NA				

1/ The rating value in 1976 subtracted from the rating value in 2010 yields ΔR.

This 100 rating was broken down into a rating for each trend, and each trend rating was further broken down into the regional ratings of that trend. The same implication assessment of trends was made for 2010, using 1976 as the baseline. This shows an 11 point reduction in overall implications; thus, silviculture trends in 2010 will have significantly fewer adverse effects upon environmental quality.

The Silviculture Panel also rated and ranked trends using the Workshops extensiveness (E) and intensiveness (I) value system (Exhibit X-3). The procedure for arriving at these ratings differed slightly from that for the other panels because Silviculture made assessments for 1976 and

2010 intensiveness (I) values. The final rating value was derived by comparing the rating (E X I) for 1976 and the rating (E X I) for 2010. If the rating improved in 2010 (i.e., current rating was -8, and 2010 rating was -1), the overall rating (R) was positive. The panel considered this to be a beneficial effect upon the environment. If a trend became less positive in 2010, the change was judged to be adverse in effect. This procedure reflects a true change in the rating (R) of each trend.

The Silviculture Panel reflected two additional considerations in arriving at ratings and ranks for each trend. First, silviculture practices and management would be more efficient in 2010; thus, the environmental implications of silviculture would decrease. Second, aesthetics and certain ecological effects were seen as very complex issues and the panel did not feel they could assess their intensiveness adequately. Thus, these issues were not considered in intensiveness assessments. In addition to these considerations, the panel, also disregarded Alaska's forest systems in their assessments. Although Alaska's forest inventory and growth capacity are greater than that for all of the Northern region in the coterminous United States, the ultimate management of this region is still undecided.

The silviculture trends and their ranking are presented below. Their extensiveness of use and environmental implications are briefly discussed.

B. Environmental Implications of Major Trends and Practices

Each of the major silviculture and harvest management trends, as determined by Panel 5, are summarized below. Background descriptions and definitions of these trends, which served as the basis for the workshop's evaluations, are included for reference in Part C: "Background Summary," as needed.

Access to Timber (502). This was ranked the most significant environmentally related silviculture trend. Temporary access roads will continue to be built as harvest management intensifies. The maintenance and reconstruction of existing roads will increase by 2010, but construction of permanent roads will decrease to a minor level. Road building will be concentrated in the Western region. The adverse environmental effects of creating timber road access will decrease in 2010.

Site Preparation (505). This second ranked trend greatly affects the Eastern softwood forests, because of the effect of mechanical site preparation. Extensiveness of associated subtrends show no clear pattern; some increase slightly; others decrease slightly. Those log extraction practices which leave the forest site in favorable condition for regeneration will largely be Western region activities. Soil moisture control is a Southern and Lake State practice.

Extraction (503). This is ranked third and is concerned with the use of plans and specification for log extraction and the use and development of machinery for extraction. This trend and associated subtrends will increase from the current moderate usage levels to major usage levels in 2010 and will have a positive effect upon the environment.

Utilization (504). Ranked fourth, utilization has diverse implications for the future. Two subtrends--minimum size and quality extension of logs and species usage enlargement--will increase to important levels in 2010 and will have greater adverse effects upon environmental quality. A third subtrend, utilization of logging residues will decline from the present moderate usage to minor usage and will result in a beneficial environmental effect.

Fire Control (510). This was ranked number five. The prevention and detection of fires and the use of controlled burning to reduce disastrous fires will increase as new technologies and research methods are developed. Wildlife suppression control methods will continue at current usage levels. Fire control practices, judged to currently have minor adverse implications for the environment would have no implications (either beneficial or adverse) in 2010, indicating a positive change.

Growth Enhancement (508). This is ranked sixth, and associated subtrends will have increased usage in all regions in the future. Stocking by thinning methods and by the elimination of undesirable tree species will be the most extensively used of these subtrends. All practices associated with growth enhancement practices will have beneficial implication for the environment in 2010 compared to their current effects.

Type Conversion (507). Ranked number seven, this is primarily a practice of the Eastern softwood forests with only minor use in the Western region. This practice is expected to increase to moderate levels in 1985, but drop to present levels again in 2010. Its effect upon the environment will be beneficial.

Pest Control (509). This trend is ranked number eight and is used very little in any forest region. Biological and chemical agents usage will increase only slightly by 2010. Selective thinning and salvage logging to control pests will continue to be a minor practice. The environmental implications of silviculture pest control are very small.

Cutting System (501). Ranked ninth, this trend includes clear cutting, seed tree cutting, group cutting, selection cutting and shelterwood and diameter cutting practices. Of these, clearcutting is the most controversial. Some panelists felt there will be increased opposition to this practice in the future which will result in a substantial reduction in its usage. However, the panel did give a higher extensiveness rating, five, to this practice for 2010, as compared to a four rating for 1976. Other cutting systems will vary from minor use to moderate use in 2010. Cutting systems will have fewer adverse effects upon the environment in 2010, a positive change. It should be emphasized, again, that silviculture environmental ratings do not consider aesthetics or ecological disruptions values.

Stand Establishment (506). This trend, number ten, will increase in use by 2010, with the exception of natural regeneration practices. Stand establishment practices occur primarily in Eastern hardwood forests and will decline to minor levels in 2010. Stand establishment practices will have little impact on the environment.

C. Background Summary

The following descriptions and definitions of trends and management practices (subtrends) related to silviculture and harvest management were provided to the workshop participants as background for the workshop evaluation. In some cases, the trends or subtrends were modified to better reflect the panel's judgement for organizing or describing key trends and subtrends, as noted. This background summary is quasi-independent of the workshop results as described in parts A and B. However, it provides appropriate background base data, definitions and descriptions of the trends and practices assessed in this portion of the overall study.

1. Overview and Base Data

Differences in forest ecosystems, land use, and other factors dictate that the U.S. forest areas be regionally divided to determine specific needs, trends, and pollutants. These regions are the Pacific Coast region and the Rocky Mountain region (grouped together in this report under the West region), and the North and South regions. These regions will be faced with increasing demand for roundwood and sawtimber products in the future. Currently 494 million acres are in timberland, but there will be an estimated 5 percent decrease in forest land by 2010. Despite this reduction, increased demands can be met without annual cut exceeding annual growth. To meet these demands, there is a need to begin and to carry on intensive forest management, to apply science and technology, to increase the utilization of the forests, to protect growing timber, and to prevent further loss of productive timber lands.

As a result of increased fire protection, tree planting, and other forestry activities, net annual growth of both softwoods and hardwoods increased about one third between 1952 and 1970 to a total of 10.7 billion cubic feet of softwoods and 7.9 billion cubic feet of hardwoods. Exhibits X-5 and X-6 show total U.S. demand for forest woods projected to the year 2020 with amounts that can be met by U.S. forests. Based on the projections, softwood roundwood supplies will increase 29 percent between 1970 and 2020, hardwood supplies will increase 134 percent, softwood sawtimber will increase 15 percent, and hardwood sawtimber will increase 67 percent.

Exhibit X-5. Summary of softwood timber demands projected to 2020

Year	Roundwood						Sawtimber [1]					
	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests [2]	Supply-demand balance	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests [2]	Supply-demand balance
	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion board feet	Billion board feet	Billion board feet	Billion board feet	Billion board feet	Billion board feet
1952 [3]	8.4	0.2	1.3	7.3	7.3	---	39.9	0.6	2.4	38.1	38.1	---
1962 [3]	8.5	.4	1.7	7.2	7.2	---	41.7	1.1	4.6	39.2	38.2	---
1970 [3]	9.7	1.2	2.1	8.8	8.8	---	47.6	4.6	5.9	45.[illegible]	46.2	---
1970 relative prices												
1980	12.3	2.0	2.4	11.9	10.1	-1.8	59.3	6.9	6.6	59.6	48.8	-10.8
1990	13.8	2.1	2.5	13.4	10.7	-2.4	64.0	7.5	6.5	65.3	50.9	-14.1
2000	15.4	2.1	2.6	14.9	11.5	-3.4	68.1	8.1	6.4	69.3	54.2	-15.6
2010	17.2	2.2	2.6	16.8	11.6	-5.2	73.3	8.3	6.3	75.3	54.1	-21.2
2020	18.8	2.2	2.6	18.4	11.6	-6.8	77.7	8.2	6.2	75.[illegible]	53.9	-25.8
Rising relative prices [4]												
1980	11.3	2.0	3.2	10.1	10.1	---	52.4	6.9	8.9	50.4	48.8	-1.6
1990	12.1	2.1	3.9	10.3	10.7	.4	52.3	7.4	10.8	48.[illegible]	50.9	2.0
2000	12.8	2.2	4.3	10.7	11.5	.8	50.9	8.0	11.4	47.5	54.2	6.7
2010	13.9	2.2	4.4	11.7	11.6	-.1	50.7	8.2	11.6	47.[illegible]	54.1	6.8
2020	14.8	2.2	4.6	12.4	11.6	-.8	50.2	5.1	11.8	46.5	53.9	7.4
Relative prices above 1970 averages [5]												
1980	10.7	2.1	3.3	9.4	10.1	.7	49.2	6.8	9.6	46.4	48.8	2.4
1990	12.4	2.2	3.8	10.7	10.7	—	53.8	7.4	10.8	50.4	50.9	.5
2000	13.7	2.2	3.9	12.0	11.5	-.5	57.6	8.[illegible]	10.7	55.0	54.2	-.8
2010	15.6	2.2	3.9	13.9	11.6	-2.3	62.4	[illegible]	10.6	60.0	54.1	-5.9
2020	17.2	2.2	3.9	15.5	11.6	-3.9	66.3	8.2	10.5	64.0	53.9	-10.1

[1] International 1/4-inch log rule.

[2] Projections of supply are defined as the amounts of timber that would be available for harvesting if: (1) Forestry programs continued at 1970 levels, (2) timber removals in the East changed on a straight line basis from actual removals in 1970 to a balance with growth in the year 2000 and thereafter, (3) removals on private lands in the West followed trends suggested by recent management and operating practices, and allowable cuts on public lands remained at the 1970 level.

[3] Data for 1952, 1962, and 1970 are estimates of actual consumption and harvests and differ somewhat from the "trend" estimates shown in the Assessment.

[4] Relative prices rising from their 1970 trend levels as follows: Lumber--1.5 percent per year; plywood, miscellaneous products and fuelwood--1.0 percent per year; paper and board--0.5 percent per year. This would mean a cumulative increase of 62 percent for lumber by the year 2000, and 17 percent for paper and board.

[5] Relative prices of lumber and plywood 30 percent, miscellaneous products and fuelwood 15 percent, and paper and board 10 percent above their 1970 averages.

Note: Data may not add to totals because of rounding.

Sources: Data for 19[illegible]2, 1962, and 1970 based on information published by the U. S. Departments of Commerce and Agriculture.

Projections: U. S. Department of Agriculture, Forest Service.

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Exhibit X-6. Summary of hardwood timber demands projected to 2020

Year	Roundwood						Sawtimber [1]					
	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests [2]	Supply-demand balance	Total U.S. demand	Exports	Imports	Demand on U.S. forests	Supply from U.S. forests [2]	Supply-demand balance
	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion cubic feet	Billion board feet	Billion board feet	Billion board feet	Billion board feet	Billion board feet	Billion board feet
1952 [3]	3.5	[4]	0.1	3.5	3.5	---	11.6	0.2	0.3	11.5	11.5	---
1962 [3]	3.1	0.1	.2	3.0	3.0	---	11.7	.2	1.0	10.9	10.9	---
1970 [3]	3.0	.2	.3	2.9	2.9	---	12.3	.2	1.3	11.2	11.2	---
						1970 relative prices						
1980	4.3	.3	.4	4.2	5.2	1.0	16.7	.3	2.0	15.0	15.5	.5
1990	5.4	.3	.5	5.2	6.3	1.1	20.0	.3	2.0	18.3	18.2	-.1
2000	6.6	.3	.5	6.4	7.4	1.0	23.1	.3	2.0	21.4	20.6	-.8
2010	7.9	.4	.5	7.8	7.4	-.4	27.0	.3	2.0	25.3	20.6	-4.7
2020	9.3	.4	.5	8.9	7.4	-1.5	30.9	.3	2.0	29.2	20.5	-8.7
						Rising relative prices [5]						
1980	3.9	.3	.5	3.7	5.2	1.5	14.9	.3	2.0	13.2	15.5	2.3
1990	4.5	.3	.5	4.3	6.3	2.0	16.4	.3	2.4	14.3	18.2	3.9
2000	5.4	.3	.7	5.0	7.4	2.4	18.0	.3	2.7	15.6	20.6	5.0
2010	6.2	.4	.8	5.8	7.4	1.6	19.9	.3	2.8	17.4	20.6	3.2
2020	7.3	.4	.8	6.9	7.4	.5	21.6	.3	2.9	19.0	20.5	1.5
						Relative prices above 1970 averages [6]						
1980	3.9	.3	.6	3.6	5.2	1.6	14.3	.3	2.4	12.2	15.5	3.3
1990	4.8	.3	.6	4.5	6.3	1.8	17.1	.3	2.4	15.0	18.2	3.2
2000	5.9	.3	.6	5.6	7.4	1.8	20.0	.3	2.4	17.9	20.6	2.7
2010	7.0	.4	.6	6.8	7.4	.6	23.6	.3	2.4	21.5	20.6	-.9
2020	8.2	.4	.6	8.0	7.4	-.6	27.1	.3	2.4	25.0	20.5	-4.5

[1] International 1/4-inch log rule.

[2] Base projections of supply are defined as the amount of timber that would be available for harvesting if: (1) Forestry programs continued at 1970 levels, (2) timber removals in the East changed on a straight-line basis from actual removals in 1970 to a balance with growth in the year 2000 and thereafter, (3) removals on private lands in the West followed trends suggested by recent management and operating practices, and allowable cuts on public lands remained at the 1970 level.

[3] Data for 1952, 1962, and 1970 are estimates of actual consumption and harvests and differ somewhat from the "trend" estimates shown in the Assessment.

[4] Less than 50 million cubic feet.

[5] Relative prices rising from their 1970 trend levels as follows: Lumber--1.5 percent per year; plywood, miscellaneous products and fuelwood--1.0 percent per year; paper and board--0.5 percent per year.

[6] Relative prices of lumber and plywood 30 percent, miscellaneous products and fuelwood 15 percent, and paper and board 10 percent above their 1970 averages.

Note: Data may not add to totals because of rounding.

Sources: Data for 1952, 1962, and 1970 based on information published by the U. S. Departments of Commerce and Agriculture.

Projections: U. S. Department of Agriculture, Forest Service.

In the South region, softwood is the principal product. Management is for existing pine trees with conversion of some other forest areas to softwood production. Silviculture in the South region is in the developmental stages and has the largest growth potential of all the regions. In the West region, emphasis is on harvesting old growth stands. The North region is very large and has a wide variety of forest types, but it contributes a smaller proportion of national roundwood production. By 2010, the North may produce 25 percent of the total U.S. roundwood supplies.

Silviculture practices result in some pollutants that affect environmental quality. These practices include forest fertilization, pesticide application, mechanical forest operations, the construction, maintenance, and usage of logging roads, prescribed and slash burnings, and logging techniques.

Logging road construction, maintenance, and usage and mechanical forest operations are thought to have the most significant environmental impacts. Mechanical forest operations can compact the soil and decrease soil productivity, destroy wildlife habitat, and leave the soil exposed for potential erosion. Recovery from this soil compaction normally takes 3 to 10 years when soil undergoes freezing and thawing, but it takes much longer when this does not occur. Increased erosion losses will accompany logging road construction, and with poor management, stream sediment loads can greatly increase. Road construction will continue to increase to 2010. Access roads to the national forest system in the West region will increase to 14,000 Km by 1977 and to 18,000 Km by 2010. These additional roads will also increase access to public recreational areas.

Pesticide and fertilizer applications occur at infrequent intervals in forest land. Applications are usually made on a rotational basis with only a small fraction of the total land area receiving chemical or nutrients at any one time. During a 30 to 80 year period, each will receive applications only two or three times. In 1972, only .002 percent of the commercial forest land received insecticide applications, and while 10.6 million acres are available for fertilization, less than 500,000 acres will receive fertilizer application in one year. Consequently, fertilizer and pesticide concentrations are minor compared to those from productive agriculture usage. They are probably not significant pollutants of water and air.

Logging techniques result in logging residues which have impacts on the aesthetic quality of a forest and are potential fire hazards. Water yield is increased when trees are cut and this may be of benefit if cutting occurs when or where water is scarce. Where wildlife is affected by logging practices, each cutting method will favor some species and be detrimental to others. Clear-cutting practices may, under unusual conditions of steep topography and loose soil underlaid by impermeable rock formations, result in increased sediment and nutrient loading of streams.

Prescribed and slash burnings change wildlife ecologies, create temporary air pollution from smoke, and destroy the forest humus and vegetation that is often needed to prevent erosion losses (usually a short term effect). When vacancies are created in the available growing space by the death or removal of a species, the remaining vegetation or a new species quickly fills the vacancy.

2. Trends and Environmental Implications

Forest products originate from a variety of different forest types, a diversity that results from the distinct ecological conditions that characterize the various forest regions of the country. Assessments of the impact on the environment of the silvicultural production system require an examination of the industry on both the national and regional levels.

Flow chart. Exhibit X-7 "Silviculture Production Systems" clarifies the interrelationship of the many factors involved in the silvicultural production system. This flowchart shows that the environmental impacts begin at the middle level of the chart under "Resource Management" and filter downward. The magnitude of these impacts (either positive or negative) are influenced by developments portrayed at the top level under "Science and Technology," and how these are, in turn, used at the next level, "Resource Inputs."

Trends. The specific silviculture practice trends have been grouped in Exhibit X-8, "Environmentally Related Trends," under the following headings: (1) timber harvesting, (2) stand control, and (3) damage control. This grouping provides a convenient framework for the next step in the analysis, i.e., that of rating the trends in the order of their overall environmental importance based upon their extensiveness of use and intensiveness of effect.

Exhibit X-9, Description of Trends and Developments, explains the meaning of terms used.

Environmental implications. Silviculture practices will have effects or potential effects upon the environment. Water quality, soil productivity, air, aesthetics, and ecology will be affected to some extent. Although regional differences will exist with regard to practices and the environment, generalized conclusions can be made on environmental impact.

Sediment losses to streams are associated with road construction, logging practices, mechanical soil preparations, controlled burns, and occasionally from clear-cutting. Sediment losses from these practices are usually short term in effect. Vegetation cover regenerates quickly in forested areas and after harvesting, a forest area may not be entered for cutting for several years, so potential erosion situations will arise infrequently. Forest areas contribute only 14 percent as much sediment as agricultural croplands. In light of this data, water quality does not usually suffer significantly from forest sediment sources.

Exhibit X-7. Silvicultural production system

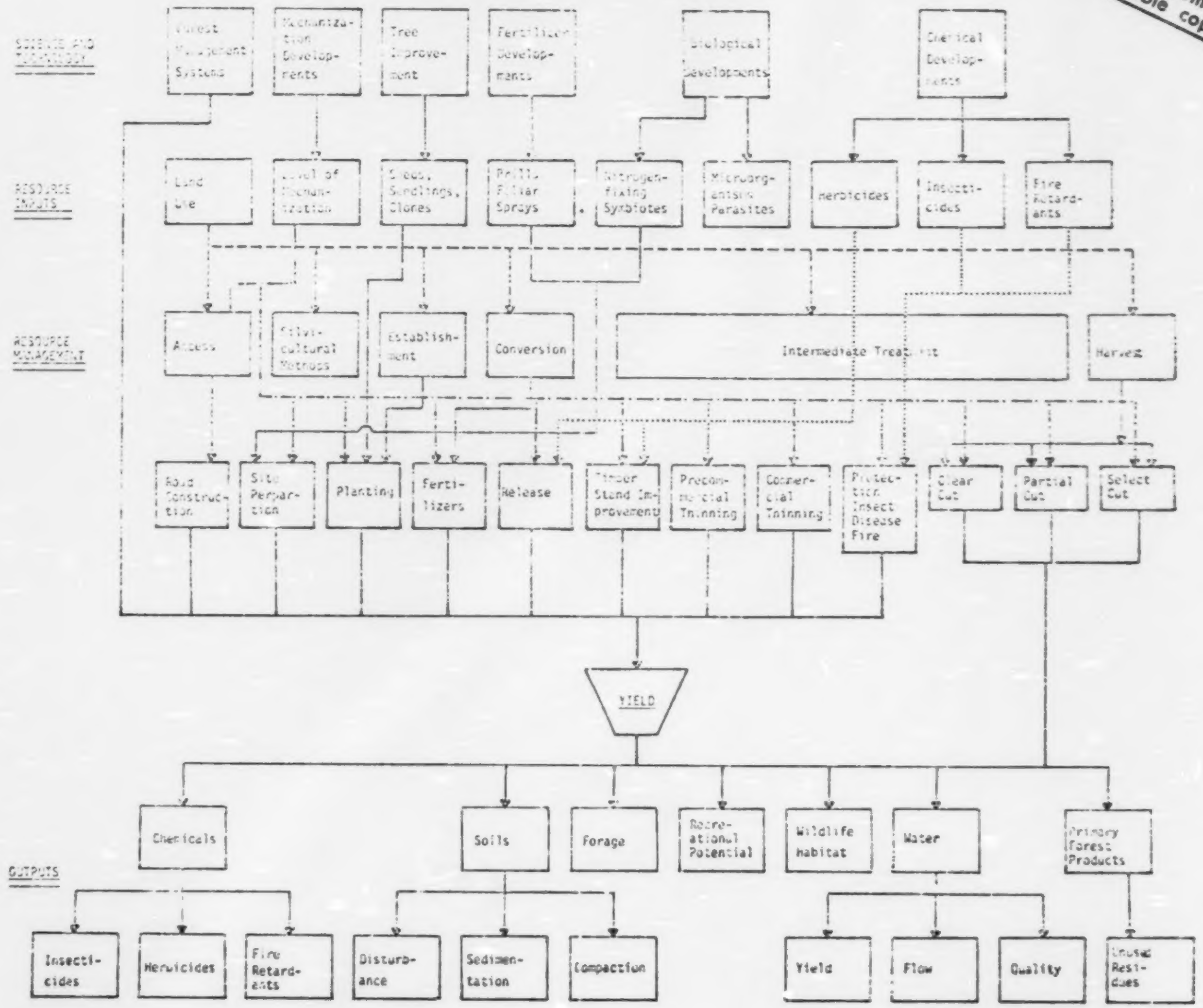
SCIENCE AND TECHNOLOGY
RESOURCE INPUTS
RESOURCE MANAGEMENT
OUTPUTS
Forest Management Systems
Mechanization Developments
Tree Improvement
Fertilizer Developments
Biological Developments
Chemical Developments
Land Use
Level of Mechanization
Seeds, Seedlings, Clones
Prill, Foliar Sprays
Nitrogen-fixing Symbiotes
Microorganisms Parasites
Herbicides
Insecticides
Fire Retardants
Access
Silvicultural Methods
Establishment
Conversion
Intermediate Treatment
Harvest
Road Construction
Site Preparation
Planting
Fertilizers
Release
Timber Stand Improvement
Precommercial Thinning
Commercial Thinning
Protection Insect Disease Fire
Clear Cut
Partial Cut
Select Cut
YIELD
Chemicals
Soils
Forage
Recreational Potential
Wildlife Habitat
Water
Primary Forest Products
Insecticides
Herbicides
Fire Retardants
Disturbance
Sedimentation
Compaction
Yield
Flow
Quality
Unused Residues

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Exhibit X-8. Environmentally-related trends: Silviculture

TIMBER HARVESTING TRENDS

501. CUTTING SYSTEM USE
    a. Clear cutting
    b. Seedtree cutting
    c. Group cutting
    d. Single-tree cutting
    e. Shelterwood

502. ACCESS ENLARGEMENT
    a. Road construction
    b. Road maintenance

503. LOG EXTRACTION METHOD CHANGE
    a. Engineering layout
    b. Equipment use and development

504. UTILIZATION INTENSITY CHANGE
    a. Log extraction residue recovery
    b. Log minimum size extension
    c. Species use enlargement

STAND CONTROL TRENDS

505. PLANTING SITE IMPROVEMENT
    a. Log extraction method prescription
    b. Mechanical preparation
    c. Burning prescription
    d. Chemical treatment
    e. Fertilizer treatment

506. STAND ESTABLISHMENT
    a. Species selection
    b. Planting material selection and/or development
    c. Planting method
    d. Stocking control by spacing

507. STAND CONVERSION
    a. Species replacement
    b. Stand composition enhancement

508. GROWTH ENHANCEMENT
    a. Stocking control by thinning
    b. Undesirable species elimination
    c. Fertilization, chemical composition, method of application

Exhibit X-8 (continued)

DAMAGE CONTROL TRENDS

509. INSECT AND DISEASE CONTROL
  a. Use of chemical agents: pesticide development and application
  b. Mechanical treatment: selective thinning, salvage logging
  c. Use of biological agents: attractants, repellants, pheromones, sterilants, parasites

510. FIRE CONTROL
  a. Prevention method improvements: hazard reduction, risk identification, public education
  b. Detection method improvement
  c. Fire use method improvement
  d. Wildfire control method improvement

Exhibit X-9. Description of trends and developments: Silviculture and Harvest Management

TIMBER HARVESTING TRENDS

501. CUTTING SYSTEM USE

a. Clear cutting: The removal in one cut of all trees on an area. The area may be regenerated from residual reproduction or by natural or artifical methods after cutting.

b. Seed tree cutting: The removal of all trees in one cut except for a few of the better seed-producing trees of desired species which are left well dispersed over the area to provide seed for regeneration.

c. Group cutting: The removal of all tree size classes in selected groups up to 2 acres. Regeneration occurs in the group openings under conditions similar to those found in small clearcuts.

d. Single-tree cutting: The removal of individual trees of a pre-determined size, quality, growth rate, and species. Regeneration is established under the shade of the remaining trees after each cut.

e. Shelterwood: Any regeneration cutting in a more or less regular or mature crop designed to establish a new crop under the protection of the old.

502. ACCESS ENLARGEMENT

a. Road construction: Establishment of forest roadways for the transportation of forest products and forest administrative activities.

b. Road maintenance: Activities organized to keep roadways operable.

503. LOG EXTRACTION METHOD CHANGE

a. Engineering layout: Plans and specifications for log extraction systems.

b. Equipment use and development: Application of production machinery to log extraction and development of new machinery and methods of application.

504. UTILIZATION INTENSITY CHANGE

a. Log extraction residue recovery: Finding ways and methods of utilizing waste material now left in the forest after log extraction.

b. Log minimum size extension: Develop methods for using

Exhibit X-9 (continued)

smaller diameter and shorter length logs than being extracted by present use systems.

c. Species use enlargement: Extension of utilization systems to tree species now considered non-commercial.

STAND CONTROL TRENDS

505. PLANTING SITE IMPROVEMENT

a. Log extraction method precription: Institute specifications for log extraction methods that will leave the planting site for the regeneration of a new timber stand in the most favorable condition.

b. Mechanical preparation: Use of machinery to establish favorable site conditions for tree regeneration.

c. Burning precription: Specifications for the use of fire to establish site conditions favorable for tree regeneration.

d. Chemical treatment: Use of chemical formulations to enhance site conditions for tree reproduction.

e. Fertilizer treatment: Application of fertilizing preparations to enhance site conditions for tree reproduction.

506. STAND ESTABLISHMENT

a. Species selection: Organize programs to find tree species best suited for planting site to be regenerated to forest trees.

b. Planting material selection and/or development: Organize programs to determine the best type of planting material (seedlings, cuttings, etc.) from the species selected. Establish programs to produce such material.

c. Planting method: Selection of the way to plant tree species chosen for regeneration program that will produce the most favorable result under conditions found on the planting site.

d. Stocking control by spacing: Establish specifications for distance between planting stock that will provide the most favorable tree stand density considering planting site conditions and potential for survival of planting stock once planted.

507. STAND CONVERSION

a. Species replacement: Institution of programs to eliminate undesirable species and establish in their place species of greater value.

Exhibit X-9 (continued)

b. Stand composition enhancement: Taking measures to encourage or favor the reproduction and growth of desirable species in a forest stand.

508. GROWTH ENHANCEMENT

a. Stocking control by thinning: Develop intermediate harvest programs (before final harvest cut) to attain maximum stand growth and assure that the growth occurs on the best formed individual trees or the forest stand.

b. Undesirable species elimination: Orgainze steps to destroy by by mechanical means, burning or chemical poisoning of species of no commercial value to favor of crop trees in forest stand.

c. Fertilization (chemical composition, method of application: Enhance growth potential of forest stand by formulating mixtures of chemical fertilizers and application to maximize quality and growth.

DAMAGE CONTROL TRENDS

509. INSECT AND DISEASE CONTROL

a. Use of chemical agents (pesticide development and application): Develop safe and effective chemical formulations and methods of application for control of insect and disease infestations.

b. Mechanical treatment (selective thinning, salvage logging): Using machinery to eliminate infested material from forests.

c. Use of biological agents (attractants, repellants, pheromones sterilants, parasites): Develop and apply natural biological agents to forest stands to control disease and insects.

510. FIRE CONTROL

a. Prevention method improvements (hazard reduction risk identification, public education): Reduce fire danger by identification and elimination of hazardous fuel conditions. Inform the public to reduce man-caused fires.

b. Detection method improvement: Develop better ways to discover potentially destructive fires while they are small and controllable.

c. Fire use method improvement: Find better ways to use fire to reduce potential for disastrous, uncontrollable fires.

d. Wildfire control method improvement: Continue and enlarge programs to develop better strategies, equipment and organizationalsystems for wildfire supression.

Water levels in streams are increased by timber cutting which will benefit areas where water is scarce and have limited effect in other areas. Cutting of a large area in a moist climate could create a temporary potential for flooding situations. Increased water levels are short term and will return to normal levels with new tree growth.

Logging residues that reach streams create barriers to fish migration, trap sediment, and make demands on stream BOD levels. Careful logging management reduce these dangers so that little environmental impact will result.

Increased water temperatures resulting from streamside cutting will benefit streams that are too cold for some fish species or growth of adequate food supplies but may be detrimental to some cold water fish. Buffer zones between streams and cutting will prevent increased stream temperatures. Total impact on the environment will be small.

Nitrogen and phosphorus levels in streams are not expected to increase significantly from the amount of fertilizers used in silviculture. Only a small forest area receives fertilization each year. The impact of these nutrients on streams will be insignificant.

Soil nutrient deficiencies resulting from timber cutting may become a problem with total tree removal practices. Whole tree removals can remove four and a half times more nutrients from soil than stem removal. Should this practice increase on a large scale, forest soil could become deficient in some nutrients requiring increased fertilization. Currently, loss of nutrients from soil is not an environmental problem.

Soil compaction by heavy machinery during logging operations result in decreased soil productivity. In some areas, 29 percent of total soil at a logging site may become compacted. While mechanical operations may not occur in that area again for several years, the soil will take three to ten years, minimum, to recover from compaction. Use of lighter, more mobile equipment, cable systems, and aerial logging will tend to reduce soil compaction. Total impact of soil compaction is of minor significance.

Forest residues from logging deter from aesthetics and create potential fire hazards. Whole tree logging, increased uniformity in tree size and quality, plus clean-up operations minimize residue problems. Environmental impact will be small except in some West region areas where old growth liquidation coincides with high recreation use of forests.

Air pollution from smoke, dust, and pesticide residues will be short term and probably produce no lasting ill effect on the environment.

Changes in vegetation, overgrowth, old tree stands, and foliage will affect the forest wildlife and habitat. While some environmentalists feel that any change in forests will be detrimental to wildlife, each cutting practice will benefit some wildlife species and be harmful to others.

SECTION XI

WORKSHOP RANKING OF MAJOR TRENDS ACROSS PANELS

An additional goal of this study was to assess the overall importance of major trends across the five panel areas. Each panel, having identified the top five trends in its area, presented these trends to the entire workshop with the rationale of their importance. The reasons given included both the extensiveness of use and the intensiveness of effect of the trends and their environmental assessments projected to 2010. Also, the professional knowledge and judgments developed in the panel sessions were summarized. Each of the five panels was then asked to assess and rank from 1 to 25 the five major trends from all panels.

The Silviculture and Harvest Management Panel, after long discussion and with the consent of the Contractor, ranked only the top five trends identified within its own panel area and did not rank the top trends of the other four panels. As explained previously, the Silviculture Panel felt it lacked the expertise to assess the importance of agricultural trends and its assessment would only dilute the judgments of the agricultural experts. Also, the Silviculture Panel generally felt that forestry management trends should be assessed separately from agriculture due to distinct differences in the growth cycles of forests vs. agriculture cycles, and other factors.

Exhibit XI-1 presents the workshop ranking of the twenty major agricultural trends, five from each panel with the panels as follows:

1. Nonirrigated Crop Production
2. Irrigated Crop Production
3. Feedlot Production
4. Range and Pasture Management

This workshop rank was determined from a summary of the rankings by Panels 1, 3, and 4. Panel 2 did rank the twenty trends but used a different rating system to arrive at a rank number. This panel began with the number one trend from each of the four panels and ranked it from one to four, the second trend of each panel was ranked from five to eight and so on, although additional shifts were made thereafter. The other panels ranked the trends in what they assessed as the order of overall national importance. In theory, all the trends from one panel could have been judged the most important by the workshop and ranked one through five. For this reason, the rankings from Panel 2 were not used to arrive at a final workshop rank for each trend.

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Exhibit XI-1. Summary of workshop rankings of major trends in agriculture and silviculture

Agriculture Trends	Workshop Rank 1/ Determined from Panels 1, 3, 4 2/
(104) Runoff and Erosion Control (Nonirrigated)	1
(101) Conservation Tillage	2
(203) Improved Water Application	3
(204) Runoff and Erosion Control (Irrigated)	4
(119) Improvement of Seed and Plants	5
(120) Scouting and Integrated Controls	6
(121) Developing New Biological and Chemical Pesticides	7
(319) Feedlot Design for Waste Management	8
(308) Feedlot Size	9
(317) Feedlot Residual Disposal	10
(211) Method of Nutrient Application	11
(406) Grazing Practices: Range & Pasture	12
(405) Stocking Rates: Range & Pasture	13
(220) Developing Integrated Controls	14
(401) Range & Pasture Renovation	15
(210) Using Plant & Soil Analysis	16
(313) Odor Control	17
(416) Using Increased Resources: Range & Pasture	18
(318) Feed Efficiency and Rations	19
(417) Range and Pasture Improvement	0

Silviculture Trends	Rank by Panel 5 2/
(502) Access to Timber Resource	1
(505) Site Preparation	2
(503) Log Extraction	3
(504) Utilization (Logs & Residues)	4
(510) Fire Control	5

1/ Panel 2 was excluded from this summary since they used a different ranking system for the twenty major trends.

2/ Panels:
(1) Nonirrigated Crop Production
(2) Irrigated Crop Production
(3) Feedlot Production
(4) Range and Pasture Management
(5) Silviculture and Harvest Management

Analysis of the Workshop rank of the twenty trends shows that all five trends from Panel 1, Nonirrigated Crop Production, are ranked within the first seven places. These rankings indicate that nonirrigated crop production trends will be a relatively important agricultural influence on environmental quality (both beneficial and adverse).

Runoff and Erosion Control (104) was ranked as the number one trend of the workshop, with Conservation Tillage (101) ranked number two, implying that both will be of major environmental concern in 2010. Comparisons of the rankings of the individual panels, show that all three panels ranked Runoff and Erosion Control, number one, and Conservation Tillage, number two. (See Appendix for comparisons of panel rankings of the major twenty trends.)

Trends from Panel 2, Irrigated Crop Production, range from number three to number sixteen. Improved Water Application (208) and Runoff and Erosion Control-Irrigated (204) trends were included with the five trends of Panel 1 to complete the top seven. Trends from Feedlot Production, Panel 3, had a high ranking of eight and a low ranking of nineteen. The workshop ranks of these two panels indicate that some trends in each will be very important to environmental quality in 2010. Other trends from these panels will have an effect, but were judged to have neither the extensiveness of use nor the intensiveness of effect upon the environment as compared to other trends.

Pasture and Range Management trends, Panel 4, were clustered in the bottom half of the twenty. These trends ranged from number twelve to number twenty.

The top five trends of Silviculture and Harvest Management, Panel 5, are included in Exhibit XI-1. While Silviculture did not rate agricultural trends across panels, the other four panels did rate silviculture trends along with their trends. In summary, these rankings placed silviculture trends in the bottom half of the trend placement. In general, the Workshop concurred that substantially more quantitative measures are important before the environmental implications of silviculture can be appropriately cross-ranked with agriculture.

Exhibit XI-2 shows the rank each trend had within its panel, the rank each trend received from its own panel when integrated into the top twenty, and final workshop rank of each trend. Panels 1 and 2 changed the relative order of their trends when putting them in the major twenty. Panel 1 reversed the order of two trends, while Panel 2 changed the order of four trends, and combined trend 204 with trend 104, and trend 220 with trend 120. The rankings by Panels 1 and 4 of their trends closely paralleled the final workshop rank of these same trends.

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Exhibit XI-2. Panel's ranking of their top five trends within twenty major trends

Panel	Trend	Initial Panel Rank of Top Five Trends	Panel's Rank of Their Trends in Twenty	Workshop Final Rank of Trends
1. Nonirrigated Crop Production	(104) Runoff & Erosion Control	1	1	1
	(119) Improvement of Seeds & Plants 103 + 114)	2	3	5
	(101) Conservation Tillage	3	2	2
	(120) Scouting & Integrated Controls (112 + 117)	4	6	6
	(121) Developing New Biological and Chemical Pesticides (115 + 116)	5	7	7
2. Irrigated Crop Production	(208) Improving Water Application	1	2	3
	(204) Runoff & Erosion Control	2	1 1/	4
	(211) Methods of Nutrient Application	3	6	11
	(220) Developing Integrated Controls	4	5 2/	14
	(210) Using Plant & Soil Analysis	5	12	16
3. Feedlot Production	(303) Feedlot Size	1	3	9
	(315) Feedlot Design for Waste Management (306 + 311 + 312)	2	5	8
	(317) Residual Disposal (312 + 315)	3	6	10
	(312) Odor Control	4	15	17
	(313) Feed Efficiency & Ration (302 + 305)	5	18	19
4. Range & Pasture Management	(406) Grazing Practices: Range & Pasture	1	12	12
	(405) Stocking Rates	2	13	13
	(401) Range & Pasture Renovation	3	14	15
	(416) Using Increased Resources (411 + 415)	4	18	18
	(417) Range & Pasture Improvement (402 + 404 + 407)	5	19	20
5. Silviculture and Harvest Management	(502) Access to Timber Resource (Woods)	1 3/		
	(505) Site Preparation	2		
	(503) Log Extraction	3		
	(504) Utilization (Logs & Residues)	4		
	(510) Fire Control	5		

1/ Ranked Number 1 along with (104).

2/ Ranked Number 5 along with (120).

3/ Silviculture trends were rated separately by silviculture panel only and are not included in top twenty trends.

Individual participants were also given the opportunity to rank the top trends without regard to panel preference. While emphasis of the workshop was on judgements and assessments of panels and not on individuals, note should be made of the summary of rankings by the individual participants (see Appendix). This assessment shows a ranking that follows the overall Workshop ranking very closely, with the biggest change in any rank by only three places. Individual participants would seem to have placed confidence in the overall Workshop rankings of the major trends.

Participants were also given the opportunity to integrate other trends from their panel into the top twenty. Of most significance was the Wind Erosion Control (106) trend from Panel 1. Several panel members thought that this trend was important enough to be considered in the top twenty trends. This is a good reminder that the twenty major trends in agriculture are "limited" to only five from each panel--as prescribed by the procedures of the Workshop. The major twenty trends presented should not necessarily imply the top twenty trends, but rather, they do indicate relative importance under the terms of the Workshop.

SECTION XII

CONCLUSIONS AND RECOMMENDATIONS

In reviewing the contractor's preliminary findings, the Evaluation Workshop provided the desired assessments of environmental implications of trends in agriculture and silviculture. Development Planning and Research Associates, Inc. reached the following conclusions regarding the workshop's judgements. Also, recommendations concerning future efforts with this type of workshop assessment are presented below.

A. Conclusions

In reference to the preceding summarization of the workshop findings, four main conclusions are highlighted:

1. Panel Rankings. Each panel reached a consensus opinion of how the trends or developments in its area should be ranked relative to its associated environmental effects. These panel results are clearly a key conclusion of the workshop, and the U.S. Environmental Protection Agency can advisedly follow the panels' ranking of these major trends -- realizing, importantly, both the beneficial and adverse dimensions of the component subtrends within each trend.

2. Workshop Rankings. The workshop also ranked five major trends from each panel area (agriculture panels only). This ranking, from 1 to 20 for the four agriculture panels, was the second important result of the workshop for it establishes an overall priority of concern for environmental effects emanating from the agricultural sector.

   The silviculture sector was regarded as distinctly different from the agriculture sector, primarily due to the longer growth cycle of forest production. Consequently, the trends of silviculture were not officially cross-ranked with the trends of agriculture--although the agriculture panels did integrate silviculture trends with their trends and placement of silviculture trends was in the lower half of major ranked trends. Certain aesthetic, wildlife habitat, and ecological issues associated with silviculture production and harvest management were not adequately resolved within the silviculture panel (which would add to this panel's ratings); and, thus, cross panel comparisons were, perhaps, indeed premature.

3. Relative Ratings Within Panels. A third valuable result (and conclusion) of the workshop was the assignment of adjusted ratings, AR, to each of the panels trends (which was used to determine each trends ranking). These ratings, as presented above, are a further enumeration of the panel's judgement of the relative environmental importance of each of the trends. (Note, however, that these panel ratings should not be compared across panels, only within each panel.)

   As required by the workshop, the panels were to present a composite panel rating. Individual judgements within a panel may have differed from the final ratings; however, the panel's conclusions were the primary results sought by the Workshop.

4. Diversity of Segments. Agriculture and silviculture represent major sectors of the economy which are diverse not only in management and production procedures but also in their environmental implications. The major environmental concerns in agriculture involve direct effects on soil, air, and water quality and indirect effects, primarily on the human food chain. In silviculture, considerable concern surrounds the indirect environmental effects involving ecology, aesthetics, and recreation.

   Substantial differences in environmental implications exist among specific segments within agriculture. Crop production activities are non-point sources of pollution; feedlot operations are classified as point-sources. Range and pasture management take on aspects of both agriculture and silviculture. The problems and concerns of each of the segments are not only diverse in operations but are also, in many cases, regionalized. Irrigated crop production occurs predominately in the western 17 states while nonirrigated production occurs primarily in the eastern United States. Types of timber harvesting vary significantly between regions. Because of this diversity in operations, environmental implications, and regions involved, the various segments will require focused attention as a requirement for an effective environmental program.

B. Recommendations

As a byproduct of the workshop experience, and not as a planned result, several recommendations can be offered for future efforts to further the assessment of the environmental implications of trends in agriculture and silviculture. The suggestions are briefly presented below.

Special Note. These recommendations do not include DPRA's input to EPA concerning Phase II of this overall study, i.e., evaluation of the environmental impacts (vs. implications) of selected key trends. However, this Evaluation Workshop Summary will be the principal basis for DPRA's recommendations for Phase II.

1. Regionalization of Trends. While it was anticipated that regional variations in trends or developments would exist, the panels would have generally preferred that the rating system be regionalized so that known regional differences could have been pinpointed. Further studies of this type should isolate important regional variations in trends.

2. Segmentation of Panel Areas. In some instances, a further segmentation of a panel's area, e.g., species categories in Livestock, or ranges plus pastures in Range and Pasture, would have been desirable. This was largely accomplished by the Range and Pasture Panel by first assessing each component--which were then aggregated. However, it appears that providing for segmentation within the prepared forms would generally be desirable, although, thereafter, the aggregation process was found feasible.

3. Additional Trends. Because of the time constraints for completing the required forms, most panels had little time to consider the addition of trends (and subtrends) to those provided by the Contractor. This is not to say that the major trends were not identified and rated; however, a more elaborate enumeration of trends, and especially possible developments, could have been generated by the panels.

   The Contractor recommends that future efforts include time allotments for the generation of additional trends and probable developments which may have significant environmental implications.

   Related to this limitation, time was also not available to pursue the relative importance of secondary trends, e.g., trends 6 to 10, of each panel area. Individual summaries were obtained, but no overall workshop evaluations were possible. To some extent the relative adjusted ratings may be used to approximate the overall ranking of secondary trends, but further assessment is warranted.

4. Quantified Environmental Data and Environmentalist Representation. There was general agreement that sufficient quantitiative data on the environmental effects of specific agricultural and silvicultural practices (trends or subtrends) do not generally exist. When available, such data tend to be site specific (a desirable attribute), but the consequences cannot be readily generalized to regions or the nation. Obviously, more quantified data are desired, but in the meantime considered value judgements are needed.

   The workshop format was designed to predominantly include professionals within agriculture and silviculture who are knowledgeable both of the trends and of associated environmental effects. Presumably more emphasis could be given toward inclusion of environmental professionals whose emphasis is not necessarily agriculture or silviculture technology or production. This may have altered the focus of the workshop, however.

The plan of study is to incorporate both more quantitiative data (as available) and more environmentalist input in the Phase II-Evaluation of the impact (vs. implication) of selected trends in agriculture and silviculture. Also, however, future workshops which have either a narrower focus, and/or a more established ordering of key trends may well benefit from the addition of more professional disciplines which would broaden the scope of understanding of environmental effects of trends and developments.

5. Public and Private Support of Trends. Throughout the panels' evaluations, a recurrent theme was that if a given trend is fostered through public and private channels, then the environmental implications will be major, etc. In other words, various trend assessments were conditional evaluations such that if "A" happens then "B" will follow. The workshop instructions were for the participants to make collective judgements as to the expected outcome of each trend given their knowledge of current and expected socio-economic-political conditions. In many cases, the underlying trends or possible developments do require continued support by local-state-federal governments if the trends are to be realized.

   Future workshops might benefit from a more explicit evaluation and summarization of associated supporting legislation to foster selected trends and developments. This workshop relied primarily on the knowledge and measurements made by the respective panel participants.

6. Rating System Improvements. Each of the panels utilized the rating system definitions effectively to determine the desired rankings within their panel area. However, the rating system, as defined, allowed for variation in use when assessing changes over time. As a recommendation, the procedures utilized by the Silviculture Panel most nearly capture the intent of the workshop--which assesses the 2010 environmental implications as compared to 1976 (current) by first "defining" the current period rating. Subsequently, the changes in environmental effects are more rigorously defined.

   The other panels implicitly defined current period environmental effects but assessed changes only. Again, each panel resolved the rating system issues to their own satisfaction so that their ratings within panels are valid. The across-panel ratings were specifically determined without reliance on the adjusted ratings which were stressed as panel values only.

7. Time Frame. The time frame for the assessment was from 1976 to 2010. A short-term period, i.e., 1985, was also designated vs. the long-term period of study, i.e., 2010. The workshop focused on the 2010 period only due to the limited time available for review by the participants. Further study of the short-term, as well as long-term, data contained in this summary is warranted and planned in Phase II.

Further research in this area of study may justifiably include greater emphasis on the distinction of short-term vs. long-term environmental implications of trends in agriculture and silviculture. An expressed observation by the workshop itself was that the "beneficial" results by 2010 may not be fully realized by 1985; and, hence, the short-term effects may tend to be "adverse." This result could compound the environmental issues associated with trends in agriculture and silviculture.

SECTION XIII

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APPENDIX A

THE EVALUATION WORKSHOP: PURPOSE AND PROCEDURES

The Contractor's preliminary assessments of trends and developments in agriculture and silviculture which have potentially significant environmental implications were submitted to a workshop evaluation in order to more usefully serve the needs of the Environmental Protection Agency (EPA). Those identified trends (and/or others specified by the workshop) were delineated on a priority basis with respect to their environmental implications--either beneficial or adverse. This was the principal task of the Evaluation Workshop.

As is readily understood by those who are familiar with the breadth and complexity of environmental issues, it is not possible to adequately document and quantify all the direct, indirect and synergistic impacts of pollutants from diverse sources that occur locally and regionally throughout our nation. Consequently, any assessment to provide a priority ranking of major environmentally-related trends in agriculture and silviculture must necessarily be based on informed judgments of qualified individuals and groups.

The participants of the Evaluation Workshop were selected because of their individual experience and expertise involving agricultural or silvicultural production and environmental implications. Collectively, these participants provided informed, and necessarily, qualitative - subjective judgments as had been requested by EPA through this study.

A. Purpose of the Evaluation Workshop

The primary purpose of the Evaluation Workshop was to rank the major environmentally-related trends and developments in agriculture and silviculture which are expected during the 1976-2010 time period. The basis for this assessment included specifically the Contractor's preliminary data findings. However, the workshop participants further assessed and modified, where necessary, the trends and developments as selectively defined by the Contractor.

Phase II of this study will incorporate the findings that emerged from the Evaluation Workshop.

B. Procedures for the Evaluation Workshop

The workshop participants were divided into five panels for the detailed trend assessments. These panels represented specific segments of agriculture and silviculture:

Agriculture

1. Nonirrigated Crop Production
2. Irrigated Crop Production
3. Feedlot Production
4. Range and Pasture Management

Silviculture

5. Silviculture and Harvest Management

Workshop participants were involved in their respective panel sessions and in general sessions to establish major trends in their specific areas of expertise and to assess the overall relative importance of major trends across the five panel areas.

To accomplish the overall objectives of the Evaluation Workshop in the time available, a formally-structured evaluation procedure was defined. This procedure involved two main components:

1. A rating system
2. A series of forms

The rating system is explained in detail in Exhibit A-1. The essence of this rating system is that each trend (or prospective development) was to be rated in relative terms for both "extensiveness of use" and "intensiveness of effect" to yield a multiplicative rating:

$$\text{Environmental Implications Rating} = \text{Extensiveness of Use} \times \text{Intensiveness of Effect}$$

or,

$$R = E \times I,$$

as defined in Exhibit A-1. Again, this procedure is a relative rating system, but it is suitable for assessing priorities as desired for the present study.

The series of forms, illustrated for Panel 1, are essentially worksheets for each panel (copies for each participant were provided) such that when the forms were "completed", the required tasks were accomplished.

In total, each panel had seven forms. These seven forms, numbered 1 to 7, e.g., Form 1-1 to Form 7 for Panel 1, were completed sequentially as explained below.

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Exhibit A-1. Rating system definition for the assessment of environment implications of trends in agriculture and silviculture

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Environmental Rating	=	Extensiveness of Use	x	Intensiveness of Effect
R	=	(E)	x	(I)
±(1-25)		(1-5)		± (1-5) [1]

where,

Rating: R = An index of the overall environmental significance of a trend or development in terms of both the scope of the trend (E) and the seriousness of the environmental implications (I) of the trend. R is the product of the ratings for E (1 to 5) and for I (± 1 to 5) as defined below.

Factor 1: E = Extensiveness of use of the trend (current or projected). Criteria shall include:

(1) geographic scope (national vs local)
(2) degree to which total acreage or sector ouput of the nation is impacted
(3) the economic importance of the trend (short-term and/or long term)
(4) Other (define)

A rating of 1 to 5 shall be qualitatively and subjectively determined for each trend or development as follows:

Rating Scale		Description
1	-	minor significance
2	-	
3	-	moderate significance
4	-	
5	-	major significance

Factor 2: I = Intensiveness of effect of the trend (including its persistence and potential irreversibility of effect). Criteria shall include:

(1) human health effects
(2) ecological system disruptions
(3) wildlife and wildlife habitat effects
(4) recreation effects
(5) aesthetic consequences
(6) agricultural (and silvicultural) production effects
(7) other (define)

A rating of ±(1-5) shall be qualitatively and subjectively determined for each "unit" of production to which the trend or development applies, i.e., irrespective of scope of the trend. A plus(+) rating denotes a positive or beneficial effect on the environment (on balance); whereas, a negative (-) rating denotes a negative or adverse effect on the environment (on balance). The ratings shall be as follows:

Rating Scale		Description
(+ or -) 1	-	minor significance
(+ or -) 2	-	
(+ or -) 3	-	moderate significance
(+ or -) 4	-	
(+ or -) 5	-	major significance

(+) = beneficial, (-) = adverse

Each factor shall be rated on a scale from 1 to 5 (E has positive values only whereas I may be either positive or negative, representing beneficial or adverse environmental effects, respectively). These factors, when multiplied, may yield an environmental rating, R, from ± (1 to 25). Relatively high absolute ratings will denote the most important environmentally related trends, whereas relatively low absolute scores will denote the less significant environmentally related trends. The sign of the rating plus (+) or minus (-) will denote whether the trend is either beneficial or adverse on an aggregate basis. Special remarks should accompany this overall rating in the case of conflicting/offsetting beneficial and adverse environmental components to explain the resolution of the conflict.

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[1] Each selected trend or development in agriculture and silviculture is to be judged based on the rating scales as defined. Relative ratings, R, across trends provides a common basis for qualitatively ranking major environmentally related trends in agriculture and silviculture.

An overriding constraint was the amount of time that each panel had to complete its assessments on each form. (Note--Panel Chairmen were designated to preside over panel discussions and assure timely completion. Any "minor" trends could be dropped from a detailed analysis to conserve time, but each panel had to so-define such trends by consensus judgment.)

The following description of the steps of the workshop were distributed to the participants and defined the use of each of the forms, the time allotted for each form, and key points regarding the step or form. Also, Development Planning and Research Associates or the Tuolumne Corporation and EPA personnel were available at each panel and general sessions to assist with procedural matters.

General Session I (Wed. 8:30-10:30 a.m.)	Step 1:	. Introduction . Overview of agriculture and silviculture . Summary of procedures
Panel Session I (Wed. 11:00-12:00 a.m.)	Step 2:	. Panel briefing and orientation
	Step 3:	. Form 1--Each panel rate trends on extensiveness of use (E) . Rating values range from 1 (minor) to 5 (major) as defined in Exhibit 1 . Note the component trends' "E" value later needed for 2010 only.
Panel Session II (Wed. 1:00-5:00 p.m.)	Step 4:	. Finish Form 1 . Form 2--Each panel rate trends on intensiveness of effect (I) . Rating values for component (a, b, c,...) trends range from ±1 (minor) to ±5 (major) where + = beneficial changes and - = adverse changes in the environmental effects. . The (I) values are to reflect changes in effects relative to current (1976) conditions from implementation of the trend or development, either + or -. . Note (I) is essentially independent of time per unit affected, e.g., acre; however, use 2010 basis if (I) affects change over time. . See Exhibit 1 for definitions.

Panel Session III (Wed. 7:30-9:30 p.m.)	Step 5:	. Form 3--Panel to integrate information from Forms 1 and 2 to derive the "absolute" environmental implications rating R as shown on Form 3. . Panels determine adjusted ratings (AR) for any trend for which further assessment is warranted. . Adjusted ratings (AR) reflect the overall relative panel ratings of trends. . Priority rankings of trends are implicit with the highest absolute value the most important of those assessed. . The AR rating may be the same as the environmental implications rating, R. A rationale for any changes should be cited.
	Step 6:	. Form 4--Each panel will determine the top five trends and their ranking, and the next five most important trends and their rankings. . These trends, and particularly the top five trends, from each panel will be submitted for overall trend assessment. . Contractor will summarize top trends from each panel for distribution.
General Session II (Thurs. 8:30-12:00 a.m. 1:00-2:30 p.m.)	Step 7:	. The Workshop will meet in general session to review and discuss each panel's findings. . The five panel chairmen will present, explain and lead discussions over the 5 most important trends as determined by each panel. . The second five most important trends may be identified, but discussion must be limited.
Panel Session IV (Thurs. 3:00-5:00 p.m.)	Step 8:	. Form 5--Each panel will rank the twenty-five trends (five from each panel) following the earlier general session explanations and discussions.

Panel Session IV (Con'd)		. Remarks on key factors involved in the final ordering (priority ranking) are to be highlighted. . The final adjusted ratings (AR) from each panel will be summarized for cross reference, but these values do not necessarily imply an overall rating.
General Session III (Fri. 8:30-11:30 a.m.)	Step 9:	. Form 6--The contractor will prepare a summary of the results of all panel's rankings of the twenty-five major trends (five from each panel). . Panel Chairmen will briefly present the rationale for their panel's rankings.
	Step 10:	. Form 7--Each participant will individually rank the twenty-five trends following the concluding rationale and discussion of all panel rankings. . Each participant is free to rank the twenty-five trends according to individual preferences without consensus from his own panel. . Results will be tabulated subsequent to Workshop.
	Step 11:	. Wrap-up of Workshop . Concluding remarks . Adjourn

Following the Evaluation Workshop, Development Planning and Research Associates, Inc. prepared the present summary of findings and conclusions of the workshop. Summary materials are to be distributed to the workshop participants and to EPA. These findings will also be inputs into Phase II of the study as previously discussed.

Modifications of the above procedures, necessitated by the work of Panels 2 and 5, are indicated in Sections VII and X of this study.

Nonirrigated Crop Production Panel

Form 1-1
Page 1 of 5

TRENDS ASSESSMENT--EXTENSIVENESS OF USE

Trend	Rating (E) */ Current	1985	2010	Remarks
101. Conservation Tillage				
a. No-tillage	1	1	2	
b. Reduced tillage	1	2	3	
c.				
102. Crop Sequencing				
a. Mono-crop sequence	1	1	2	
b. No-meadow crop sequencing	1	1	1	
c. Relay cropping	1	2	3	
d. Double cropping	2	3	4	
e.				
103. Seed/Plant Improving				
a. Weather resistance	1	2	2	
b. Salt tolerance	2	2	2	
c. Production efficiency	2	2	2	
d.				

(Continued. . .)

SAMPLE

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*/ Extensiveness rating (E), with values ranging from +1 (minor) to +5 (major), as explained in the Rating System Definition Exhibit 1.

Nonirrigated Crop Production Panel

Form 2-1
Page 1 of 5

ENVIRONMENTAL ASSESSMENT--INTENSIVENESS OF EFFECT

SAMPLE

Trend	Degree of Effect Water	Air	Soil	Other	Overall */ Intensiveness Rating (I)	Remarks
101. Conservation Tillage						
a. No-tillage	+4 &	0 &	+3 &	-4 :	+3	
b. Reduced tillage	+2 &	0 &	+2 &	-1 :	+2	
c.	&	&	&	:		
102. Crop Sequencing						
a. Mono-crop sequence	-2 &	0 &	-2 &	:	-2	
b. No-meadow crop sequencing	-1 &	0 &	-3 &	:	-2	
c. Relay cropping	+1 &	0 &	+1 &	:	+1	
d. Double cropping	+2 &	0 &	+2 &	:	+2	
e.	&	&	&	:		
103. Seed/Plant Improving						
a. Weather resistance	1 &	0 &	+1 &	:	+1	
b. Salt tolerance	+2 &	0 &	+1 &	:	+1	
c. Production efficiency	+1 &	0 &	+1 &	:	+1	
d.	&	&	&	:		

(Continued. . .)

*/ Intensiveness rating (I), with values ranging from ±1 (minor) to ±5 (major), as Explained in the Rating System Definition Exhibit 1. Use 2010 time period only as the basis.

Nonirrigated Crop Production Panel

Form 3-1
Page 1 of 5

TREND/ENVIRONMENTAL IMPLICATIONS ASSESSMENT

Trend	Original Values 1/ E	x I	= R	Adjusted Values 2/ E	x I	Adjusted Rating = AR	Remarks 3/
101. Conservation Tillage			6			9	
a. No-tillage	2	+3	6	3	+3	9	
b. Reduced tillage	3	+2	6	3	+3	9	
c.							
102. Crop Sequencing			4			4	
a. Mono-crop sequence	2	-2	4				
b. No-meadow crop sequencing	1	-2	2				
c. Relay cropping	3	+1	3	same			
d. Double cropping	4	+2	8				
e.							
103. Seed/Plant Improving			2			2	
a. Weather resistance	2	+1	2				
b. Salt tolerance	2	+1	2				
c. Production efficiency	2	+1	2	same			
d.							

1/ E is extensiveness of use rating, I is intensiveness of use rating, R is environmental implications rating, as explained in Rating System Definition Exhibit I.

2/ Changes can be made to reflect the panel's overall relative ratings of trends. AR should be reflective of the final rankings.

3/ Additional remarks may be made on back or on attached sheet.

SAMPLE

Nonirrigated Crop Production Panel

Form 4
Page 1 of 1

SUMMARY OF MAJOR TRENDS AND ASSOCIATED PANEL RATING

Trend Number and Title	Adjusted Rating (AR)	Panel Remarks
1. (118) Increased Inputs	20	Continued inputs and production will
2. (101) Conservation Tillage	9	have largest effect.
3. (116) Biological Controls	9	
4. (104) Run-off Erosion Control	8	
5. (108) Nutrient Applying	6	
6. ( )		
7. ( )		
8. ( )		
9. ( )		
10. ( )		

SAMPLE

Participant's Notes:

Nonirrigated Crop Production Panel

Form 5
Page 1 of 2

PANEL RANKINGS OF TWENTY-FIVE MAJOR TRENDS

Trend Number and Title 1/	Panel's Adjusted Rating (AR)	Remarks
1. (118) Increased Inputs	20	
2. (207) Drip Irrigation	16	
3. (221) Increased Inputs	20	
4. (101) Conservation Tilling	9	
5. (308) Increased Feedlots	12	
6. (216) Pesticide Application	9	
7. ( )	~	
8. ( )	~	
9. ( )	~	
10. ( )	~	
11. ( )	~	
12. ( )	~	
13. ( )	~	
14. ( )	~	
15. ( )	~	

SAMPLE

1/ Panel's rank 25 trends in their preferred order.

Nonirrigated Crop Production Panel

Form 5
Page 2 of 2

PANEL RANKINGS OF TWENTY-FIVE MAJOR TRENDS (Continued)

Trend Number and Title	Panel's Adjusted. Rating (AR)	Remarks
16. ( )		
17. ( )		
18. ( )		
19. ( )		
20. ( )		
21. ( )		
22. ( )		
23. ( )		
24. ( )		
25. ( )		

SAMPLE

General Summary

Form 6
Page 1 of 2

SUMMARY OF ALL PANEL'S RANKINGS OF TWENTY FIVE MAJOR TRENDS

Trend Number and Title	Panel's Rankings 1/ 1	2	3	4	5	Sum 2/ of Ranking	Participants Remarks/Notes
1. (118) Increased Inputs	1	2	8	4	1	16	
2. (221) Increased Inputs	3	1	9	3	2	18	
3. (308) Increased Feedlots	5	3	1	2	8	19	
4. (207) Drip Irrigation	2	7	2	1	9	21	limited in some regions
5. (101) Conservation Tillage	4	5	7	5	4	25	
6. (219) Biological Controls	8	4	6	6	3	27	
7. ( )	~	~	~	~	~	~	
8. ( )	~	~	~	~	~	~	
9. ( )	~	~	~	~	~	~	
10. ( )	~	~	~	~	~	~	
11. ( )	~	~	~	~	~	~	
12. ( )	~	~	~	~	~	~	

(Continued. . .)

SAMPLE

1/ Panels: (1) Non irrigated Crop Production
(2) Irrigated Crop Production
(3) Feedlot Production
(4) Range and Pasture Management
(5) Silviculture and Harvest Management

2/ The sum of the individual panel's rankings yield a value such that the lowest sum will be ranked first, the next lowest sum will be ranked second and so on.

General Summary

Form 6
Page 2 of 2

SUMMARY OF ALL PANEL'S RANKINGS OF TWENTY FIVE MAJOR TRENDS (Continued)

Trend Number and Title	Panel's Rankings					Sum 2/ of Ranking	Participants Remarks/Notes
	1	2	3	4	5		
13. ( )							
14. ( )							
15. ( )							
16. ( )							
17. ( )							
18. ( )							
19. ( )							
20. ( )							
21. ( )							
22. ( )							
23. ( )							
24. ( )							
25. ( )							

SAMPLE

Form 7
Page 1 of 2

INDIVIDUAL PARTICIPANT'S FINAL RANKING OF TWENTY FIVE MAJOR TRENDS

Trend Number and Title	Workshop Rank 1/	Individual 2/ Participant Rank	Remarks 3/
1. (118) Increased Inputs	1	2	
2. (221) Increased Inputs	2	1	Irrigated Croplands should have biggest effect on environment.
3. (308) Increased Feedlots	3	3	
4. (207) Drip Irrigation	4	7	Important in only certain U.S. sections
5. (101) Conservation Tillage	5	4	
6. (219) Biological Controls	6	8	
7. ( )	7	—	
8. ( )	8	~	
9. ( )	9	~	
10. ( )	10	~	
11. ( )	11	~	
12. ( )	12	~	
13. ( )	13	~	
14. ( )	14	~	
15. ( )	15	~	

SAMPLE

(Continued. . .)

1/ Workshop rank as determined from five panel ratings.
2/ Participants are "free" to rank according to own preference without consensus from own panels.
3/ Reasons for major shifts are requested.

Form 7
Page 2 of 2

INDIVIDUAL PARTICIPANT'S FINAL RANKING OF TWENTY-FIVE MAJOR TRENDS

Trend Number and Title	Workshop Rank	Individual Participant Rank	Remarks
16. ( )	16		
17. ( )	17		
18. ( )	18		
19. ( )	19		
20. ( )	20		
21. ( )	21		
22. ( )	22		
23. ( )	23		
24. ( )	24		
25. ( )	25		

SAMPLE

Name: ______________________
(Optional)

Area of expertise: ______________________

____

Panel: ______________________

APPENDIX B

THE EVALUATION WORKSHOPS DETAILED PANEL RATINGS

While evaluations and summaries of the workshop findings are contained within the present text, additional supporting data are provided in this Appendix. Panel rankings of the twenty major agriculture trends, individual participant rankings (voluntary) of these same twenty trends, and individual rankings (voluntary) of the second five trends (#6-#10) are shown in Exhibits B-1, B-2 and B-3, respectively

Specific workshop procedures are reviewed in the text and are not discussed further here. However, a brief discussion of all exhibits and other Appendix material is presented below.

Exhibit B-1--Summary of all panels' ranking of twenty major trends. An overall workshop rank was determined of the five major trends from each of the agriculture panels (Panels 1, 2, 3, and 4). These trends were ranked across panels, by each panel, in the order of assessed importance. While all four panels ranked each trend, the final workshop rank was determined from the rankings of Panels 1, 3, and 4 only. The rankings by Panel 2 - Irrigated Crop Production were excluded from the workshop rank because a unique ranking system was used. Basically, Panel 2 ranked the number one trend from each of the four panels from one to four, the second trend of each panel was ranked from five to eight and so on. The other panels assessed and ranked the overall environmental importance of each trend regardless of its panel's ranking. The actual rankings given to each trend and the sum of these rankings are shown in Exhibit B-1.

As stated in the text, silviculture trends (Panel 5) were not officially cross ranked with agriculture trends. The Silviculture Panel felt there were distinct differences in the growth cycles of forests and agriculture and that they also lacked the expertise to assess the relative importance of many agriculture trends. For these reasons, the trends from silviculture were not integrated into an overall workshop rank with agriculture's major trends.

Exhibit B-2--Summary of individual participant's ranking of twenty major agriculture trends. Each participant from the agriculture panels (Panels 1, 2, 3, and 4) was given the opportunity to rank the twenty major agriculture trends according to his own preference without consensus from his own panel. Ten participants responded and their rankings of each major trend are given in Exhibit B-2. Although an overall rank for each trend as determined by the individual responses is shown, it is stressed that the assessments by the panels, not by individual participants, were emphasized in the Workshop.

Exhibit B-3-- Summary of individual participants integration of second five trends (#6-#10), as identified by his panel, into major twenty trends. The workshop procedures allowed for five trends from each panel to be ranked in the major twenty trends. Other trends, ranked six through ten, within a panel, could have been judged important enough to be cross ranked in the major trends. However, these judgements were not presented within the structured portions of the workshop. Rather, on a voluntary basis, each participant was allowed to integrate any or all of the second five trends (#6-#10) identified by his panel into the major twenty trends. Out of seven responses, Wind Erosion Control (106) from the Nonirrigated Crop Production Panel was most frequently given a ranking in the major twenty.

Form 3. Environmental Implications Assessment of Trends (Panels 1 to 5). The environmental implication assessment (form 3) for all five panels is included for reference. Extensiveness of use (E), intensiveness of effect (I), environmental ratings (R), and adjusted ratings (AR), as assessed for each trend (subtrend), are shown below. All written comments made by each panel in reaching these trend ratings (taken from forms 1, 2, and 3) have been summarized for each trend. The format for the environmental implications assessment of silviculture trends differs slightly from that of the other four panels. The Silviculture and Harvest Management Panel gave an environmental implication rating (R) to trends for both 1976 and 2010. The 1976 rating was subtracted from the 2010 ratings to get the change in rating, and finally an adjusted rating was given each trend.

Workshop forms (1 to 8) and instructions. The structured forms (1-8) used by the workshop panels to assess trends were included in the previous Appendix A. Additionally, the workshop participants were given instructions and guidelines to use in completing these forms; these instructions are also contained in the previous appendix.

Exhibit B-1. Summary of all panel's rankings of twenty major trends

Work-shop Rank	Trend Number and Title	Panel & Ranking 1/ 1	3	4	Sum of 2/ Ranking from Panel 1, 3, 4	Panel & Ranking 2	Sum of Ranking from Panel 1, 2, 3, 4
1.	(104) Runoff & Erosion Control (Nonirrigated)	1	1	1	3	1	4
2.	(101) Conservation Tillage	2	2	2	6	13	19
3.	(208) Improving Water Application	5	4	3	12	2	14
4.	(204) Runoff & Erosion Control (Irrigated)	4	7	6	17	1	18
5.	(119) Improvement Plants & Seeds	3	9	7	19	15	34
6.	(120) Using Scouting & Integrated Controls	6	10	5	21	5	26
7.	(121) Developing New Biological & Chemical Pesticides	7	11	4	22	9	31
8.	(319) Feedlot Design for Waste Management	10	5	8	23	8	31
9.	(308) Feedlot Size	11	3	11	25	4	29
10.	(317) Feedlot Residual Disposal	13	6	9	28	10	38
11.	(211) Method Nutrient Application	8	14	10	32	6	38
12.	(406) Grazing Practices: Range & Pasture	12	8	12	32	3	35
13.	(405) Stocking Rates: Range & Pasture	14	12	13	39	7	46
14.	(220) Developing Integrated Controls	9	16	16	41	5	46
15.	(401) Range & Pasture Renovation	16	13	14	43	14	57
16.	(210) Using Plant & Soil Analysis	15	17	15	47	12	59
17.	(313) Odor Control	17	15	17	49	18	67
18.	(416) Using Increased Resources: Range & Pasture	18	19	18	55	17	72
19.	(318) Feed Efficiency & Rations	20	18	20	58	16	74
20.	(417) Range & Pasture Improvement	19	20	19	58	11	69

1/ Panels: (1) Nonirrigated Crop Production
(2) Irrigated Crop Production
(3) Feedlot Production
(4) Range and Pasture Management

2/ The sum of the individual panel's rankings yield a value such that the lowest sum will be ranked first, the next lowest sum will be ranked second and so on. Since Panel 2 used a different rating system to arrive at a Workshop rank number for each trend (as explained in the Appendix), only Panels 1, 3, and 4's rankings were used to determine a Workshop rank for each trend. However, the rankings given to each trend by Panel 2 are shown in the next column.

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Exhibit B-2. Summary of individual participant's ranking of twenty major agriculture trends

Trend No.	Trends	Work-shop Rank	Individual Rankings From 10 Responses										Sum of Participant's Rankings	Overall Rank by Individuals
			1	2	3	4	5	6	7	8	9	10		
(104)	Runoff and Erosion Control (Nonirrigated)	1	5	1	1	1	1	1	1	1	1	1	14	1
(101)	Conservation Tillage	2	1	3	2	3	3	3	3	2	2	3	25	2
(208)	Improved Water Application	3	3	5	3	4	2	5	2	4	3	10	41	3
(204)	Runoff and Erosion Control (Irrigated)	4	5	4	4	2	3	13	6	6	9	2	54	4
(119)	Improvement of Seed and Plants	5	2	2	5	14	7	10	12	7	6	13	78	7
(120)	Scouting and Integrated Controls	6	4	7	6	5	11	17	7	5	10	4	76	6
(121)	Developing New Biological and Chemical Pesticides	7	6	6	8	6	12	12	4	3	7	7	71	5
(319)	Feedlot Design for Waste Management	8	12	10	10	9	6	11	10	11	8	6	93	10
(308)	Feedlot Size	9	9	14	12	19	5	4	9	10	4	5	91	8
(317)	Feedlot Residual Disposal	10	14	11	11	8	8	6	11	9	5	8	91	9
(211)	Method of Nutrient Application	11	8	6	9	7	13	15	5	3	13	11	97	11
(406)	Grazing Practices: Range & Pasture	12	10	13	15	11	9	2	8	15	11	9	113	13
(405)	Stocking Rates: Range & Pasture	13	13	15	13	15	10	9	15	13	17	14	134	14
(220)	Developing Integrated Controls	14	4	9	7	13	14	16	13	12	16	12	106	12
(401)	Range & Pasture Renovation	15	15	17	19	16	16	7	14	16	12	16	148	15
(210)	Using Plant & Soil Analysis	16	7	12	17	10	15	18	17	19	20	15	150	16
(313)	Odor Control	17	17	16	18	12	19	15	20	14	19	17	167	18
(416)	Using Increased Resources: Range & Pasture	18	16	19	20	17	18	19	18	18	18	18	181	19
(318)	Feed Efficiency and Rations	19	18	20	14	18	20	20	19	20	14	19	182	20
(417)	Range and Pasture Improvement	20	11	18	16	20	17	17	16	17	15	20	167	17

Exhibit B-3. Summary of individual participant's integration of second five trends (#6-#10), as identified by his panel, into major twenty trends

Response Number	Trend No.	Trend	Partic-pant's Panel	Rank in Major Twenty
1	(309)	Geographic Concentration	3	15
2		None	3	--
3		None	3	--
4	(106)	Wind Erosion Control	1	12
	(110)	Developing Nitrogen Fixation Sources	1	14
	(173)	Improving Pesticide Application	1	14
5	(106)	Wind Erosion Control	1	18-20
6	(107)	Improving Soil-Plant Analysis (could combine with 210)	1	15
	(108)	Methods of Nutrient Applying (could combine with 211)	1	11
	(106)	Wind Erosion Control (could combine with 104)	1	16
7	(106)	Wind Erosion Control	1	13
	(113)	Improving Pesticide Application, Timing	1	15